

WATER RESOURCES DEVELOPMENT



INTERIM REPORT

POINT JUDITH

RHODE ISLAND

APPENDICES



**U.S. Army Engineer Division, New England
Corps of Engineers
Waltham, Mass.**

24 January 1962

843

APPENDICES

GLOSSARY

- APPENDIX A - HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES
- APPENDIX B - HYDROLOGY AND HYDRAULICS
- APPENDIX C - WATER RESOURCES DEVELOPMENT - DESIGN STUDIES AND
COST ESTIMATES
- APPENDIX D - NAVIGATION IMPROVEMENTS - DESIGN STUDIES AND
COST ESTIMATES
- APPENDIX E - BEACH EROSION CONTROL IMPROVEMENTS - DESIGN STUDIES
AND COST ESTIMATES
- APPENDIX F - ALLOCATION AND APPORTIONMENT OF COSTS
- APPENDIX G - FLOOD LOSSES AND BENEFITS
- APPENDIX H - PUBLIC HEARINGS AND VIEWS OF OTHER AGENCIES

GLOSSARY

HURRICANE SURGE: the mass of water causing an increase in the elevation of the water surface above predicted astronomical tide at the time of a hurricane; it includes wind set-up; sometimes the maximum increase in elevation is referred to as the surge.

HURRICANE TIDE: the rise and fall of the water surface during a hurricane exclusive of wave action.

KNOT: a velocity equal to one nautical mile (6080.2 feet) per hour (about 1.15 statute miles per hour).

OVERTOPPING: that portion of the wave runup which goes over the top of a protective structure.

PONDING: the storage of water behind a dike or wall from local runoff and/or overtopping by waves.

POOL BUILDUP: the increase in elevation of water surface behind a structure due to runoff and/or overtopping by waves.

RUNUP: the rush of water up the face of a structure on the breaking of a wave. The height of runup is measured from the still water level.

SIGNIFICANT WAVE: a statistical term denoting waves with the average height and period of the one-third highest waves of a given wave train.

SPRING TIDE: a tide that occurs at or near the time of new and full moon and which rises highest and falls lowest from the mean level.

STANDARD PROJECT HURRICANE: a storm that may be expected from the most severe combination of meteorologic conditions that are considered reasonably characteristic of the region involved, excluding rare combinations.

STILL WATER LEVEL: the elevation of the water surface if all wave action were to cease.

STORM SURGE: same as "hurricane surge".

WAVE HEIGHT: the vertical distance between the crest and the preceding trough.

GLOSSARY (Cont'd)

WAVE TRAIN: a series of waves from the same direction.

WIND SETUP: the vertical rise in the still water level on the leeward side of a body of water caused by wind stresses on the surface of the water.

APPENDIX A

HISTORY OF HURRICANES AND OTHER STORM OCCURRENCES

APPENDIX A

APPENDIX A
HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
A-1	GENERAL	A-1
A-2	SUMMARY OF HURRICANES	A-2
A-3	DESCRIPTIONS	A-16
A-4	HURRICANE TRACKS	A-32

TABLES

<u>Number</u>		
A-1	Historical Hurricanes, Rhode Island Coast	A-2
A-2	Summary of Other Notable Storms that caused High Tides, Point Judith Area	A-11

PLATES

A-1	Tracks of Selected Hurricanes
-----	-------------------------------

APPENDIX A

HISTORY OF HURRICANE AND OTHER STORM OCCURRENCES

A-1. GENERAL

In order to determine the possibility of future hurricane occurrences, a review has been made of historical data on hurricanes that have struck or threatened the coasts of Rhode Island and eastern Connecticut. A review of historical records and newspaper files indicates that a number of hurricanes and cyclonic storms have reached the coast of southern New England with devastating force, while numerous other storms have passed so close that a slight change in meteorologic conditions could have resulted in severe damage. Since Point Judith lies in the path of hurricanes moving into New England from the south it has frequently been subject to tidal flooding from hurricane surges. The records indicate that from 1635 to present the Rhode Island coast has experienced or has been threatened by hurricane tidal flooding upon 69 occasions. Of these hurricanes 32 either weakened by the time they neared Rhode Island or passed far enough away so that they did not cause tidal flooding. They did, however, present a potential threat of such flooding. Apparently 37 hurricanes caused tidal flooding. Records, exclusive of historical accounts prior to 1800, indicate that the five hurricanes which have created the most severe tidal flooding along the Rhode Island coast are as follows, chronologically:

23 September 1815
24 August 1893
21 September 1938
14 September 1944
31 August 1954

The earliest hurricanes recorded in New England are known to have affected the coastal areas of Massachusetts and Rhode Island. Since there was very little development along the shore until after 1638, there are no available records to indicate the effects of these early storms. It is reasonable to assume that they did cause inundation of the coastal lowlands. The two earliest hurricanes of record in New England, namely those of 15 August 1635 and 3 August 1638, created flood levels apparently higher than the recent floods of 1938 and 1954, and probably the greatest experienced in New England during the past 326 years.

The early hurricanes were not accompanied by so great a loss of life and property due to the lesser degree of development along the Rhode Island coast. However, the recurrence of the two earliest hurricanes under present conditions would cause extensive damages, possibly in excess of the damages sustained in September 1938.

In addition to the above hurricanes, there have been other severe storms, not necessarily of tropical origin, that caused considerable damage along the Rhode Island coast (see Table A-2).

A-2. SUMMARY OF HURRICANES

A total of 69 hurricanes which are known to have either hit or narrowly missed the Rhode Island coast is summarized in Table A-1. These hurricanes have been classified to indicate their magnitude along the Rhode Island coast as follows:

- Type "A": Hurricanes causing severe tidal flooding.
- Type "B": Hurricanes causing damage from wind and rainfall.
(usually accompanied by high seas and moderate tidal flooding).
- Type "C": Hurricanes threatening the area.

Of the 69 hurricanes, 13 are of type "A", 24 of type "B" and 32 of type "C". Forty-three of the listed hurricane experiences have occurred during the period from 1901 to 1961. The fact that there is a record of 43 hurricanes in this 60-year period, as compared with 26 in the 266-year period from 1635 to 1900, is believed to be due to lack of records and information on storms prior to 1900, rather than a trend toward increased hurricane activity in recent years.

TABLE A-1

HISTORICAL HURRICANES RHODE ISLAND COAST

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1635, Aug. 15	A	(2)(3)	"Tide at Narragansett 14 ft. higher than ordinary; 8 Indians drowned." Hit at high tide.
1638, Aug. 3	A	(3)	"Tide flowed twice in 6 hours about Narragansett and rose 14 or 15 feet above ordinary spring tide." Probably highest tide ever experienced.
1723, Oct. 30	A	(3)	"Tide one foot higher than ever known before." (Providence)
(Footnotes are at end of Table)			

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1757, June 30	C	(2)	Atlantic coast hurricane, Florida to Boston, Mass.
1761, Oct. 24	A	(3)	Very high tides in Narragansett Bay, R.I. Damage from wind and water.
1770, Oct. 19-20	A	(3)	A violent storm; immense loss of life and property along the coast.
1773, Aug. 19	C	(2)(3)	Passed near Boston, Mass. No record of damage in R.I.
1787, Sept. 19	B	(3)	Reports of damage at Stamford and Norwalk, Conn.
1788, Aug. 19	B	(2)(3)	Affected western New England much wind and rain damage in Conn. and western Mass.
1804, Sept. 8-9	C	(2)	Severe storm; passed over Cape Cod, travelling north-east. No account of damage in R. I.
1804, Oct. 9-10	B	(2)(3)	"Most furious gale experienced for many years." (Newport, R.I.)
1815, Sept. 22-23	A	(2)(3)	Tide rose 11.8 ft. above mean high tide in Providence on Sept. 23. (14.2 feet, m.s.l.)
1821, Sept. 3	A	(2)(3)	"Considerable damage was done to trees, etc. (Providence)---". Greatest intensity felt at New York where tide rose 13 feet in one hour. From Long Island, center passed inland on Sept. 3.
1829, July 24	C	(2)(3)	Reported to have been felt in Boston, Mass. No accounts of damage in Rhode Island.

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1841, Oct. 2-4	B	(2)(3)	Violent winds and heavy rain. "Some damage was done to the shipping and many chimneys were blown down." (Providence)
1854, Sept. 10-11	C	(2)(3)	Severe in southern states; passed over New England, near Boston. Described as "an old fashioned rainstorm."
1866, Oct. 29-30	B	(2)(3)	"The tide was forced by the wind to an unprecedented height---doing much damage. The water also overflowed the wharves on the east side---". (Providence)
1869, Sept. 8	A	(2)(3)	"...the wave which rolled in there (Narragansett Pier) was the heaviest ever known, but the damage was not excessive considering the violence of the storm..."
1877, Oct. 4-5	C	(2)(3)	"Severe storm of wind and rain---. The tide last evening was very high. Several yachts and boats were sunk." (Newport, R.I.)
1878, Oct. 22-23	A	(2)(3)	"Severe storm---rain falling in torrents. Some of the wharves were flooded." (Providence)
1878, Dec. 10	B	(3)	"Water in river rose very high---. Wind went down about an hour before high water." (Providence)
1879, Aug. 18	B	(2)(3)	Passed over Cape Cod. Damage from wind and rain along R.I. coast.

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1889, Sept. 10	B	(2)(3)	Accounts of high tides at Newport, R.I. No account of damage.
1893, Aug. 23-24	A	(2)(3)	"Storm struck N.Y. and moved rapidly along to Providence. Rain fell in blinding sheets. Houses shook with the force of the blast." Tide rose 3 ft. above mean high water at Providence. (5.4 ft., m.s.l.)
1893, Aug. 29	B	(2)(3)	Reports of damage from wind and tide along Connecticut coast. Large waves and heavy surf at Narragansett Pier.
1896, Sept. 9-10	B	(2)(3)	"At Block Island the storm was considered the severest on record at this season of the year. Hurricane had much of its force at sea, struck the coast east of New York City, passed over a track of territory to the south of Boston and went off to sea again."
1901, Sept. 19	C	(2)(4)	Passed south and east of Cape Cod.
1902, June 16-17	C	(2)(3)(4)	Path crossed Buzzards Bay and Cape Cod, moving northeast. Strong winds over L.I. Sound.
1902, June 29-30	C	(2)	Center passed over Conn. and southern R.I. traveling south-east; no account of damage.
1902, Oct. 12	C	(2)(3)(4)	Path south of Long Island and Nantucket, moving east.

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1903, Sept. 16	B	(2)(3)	Storm crossed northeastern Pa., moving northwest. High winds and high water along Rhode Island coast.
1904, Sept. 15	B	(2)(3)	Center passed over northeastern Conn., moving northeast. Reports of rain and wind damage and heavy surf.
1904, Nov. 13	B	(2)(4)	Passed south of Nantucket, moving northeast. Reports of wind damage.
1911, Sept. 1	C	(2)	Passed south of Cape Cod, No accounts of damage in Rhode Island. damage.
1912, Sept. 16	C	(2)	Followed easterly path across southern New England.
1916, July 21	C	(2)(4)	Passed over Providence and south of Boston, Mass. "all along the southern coast (Rhode Island) and around Point Judith the heavy surf and breakers are playing sad havoc with the traps of fishermen and lobstermen."
1920, Oct. 1	B	(2)(3)(4)	Storm passed just west of New York, heading north. Reports of damage from high tides along coast.
1923, Oct. 19	C	(2)(4)	Passed near Boston, moving northwest. Storm of slight energy.
1924, Aug. 26	B	(2)(3)	"Boats were broken up on rocks and sunk and cottages and stores along the shore at Narragansett Pier were flooded during the storm which was accompanied by the worst surf experienced in years."

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1929, Oct.. 2	B	(2)(4)	Moved northeast, passing over eastern New York and northwestern Vermont. High tides caused damage along Rhode Island coast.
1933, Aug. 23-24	B	(2)(3)(4)	Driving rain and high tides along Rhode Island coast.
1933, Sept. 16-17	C	(2)(3)	"Rhode Island took the shock of a raging storm as it passed by out at sea. Streets were flooded, trees stripped, boats beached, docks weakened, telephone service disrupted and transportation facilities crippled." (Providence)
1934, June 19	C	(2)	Travelled overland from Louisiana; crossed Long Island and Cape Cod, moving northeast.
1934, Sept. 9	B	(2)(4)	Crossed Long Island and central Conn. moving north. Wind damage along Rhode Island coast.
1936, Sept. 19	B	(2)(3)(4)	"Worst coastal storm in years swept Rhode Island shores; torrential rainfall and gale winds." Greatest intensity felt at New York.
1938, Sept. 21	A	(2)(3)(4)	At Point Judith the tide rose to 12.3 feet above mean sea level along the exposed coast and 10.5 feet above mean sea level within the Harbor of Refuge. Record flood of recent times. "It was and is the greatest disaster of any nature that has ever befallen this State." (R.I.)
1940, Sept. 2	C	(2)(4)	Passed south of Nantucket, heading northeast. No accounts of damage in Rhode Island.

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1940, Sept. 16	C	(2)(4)	Followed northeasterly path east of Cape Cod. No accounts of damage.
1943, Oct. 17	C	(2)(4)	Passed east of Cape Cod, moving due north. No accounts of damage.
1944, Aug. 3	C	(2)(4)	Moved northeasterly along path south of Long Island and Nantucket. No accounts of damage.
1944, Sept. 14-15	A	(2)(3)(4)	Center passed over Providence, R.I. and south of Boston, Mass. Tidal flooding along entire R.I. coast; "Storm came at ebb tide." Trees were uprooted, telephone and electric lines were blown down, pavements ripped up and buildings flooded.
1944, Oct. 21	C	(2)(4)	Path crossed over Nantucket and easterly tip of Cape Cod. No accounts of damage.
1945, June 26	C	(2)(4)	Followed northeasterly path from Florida to Nova Scotia, passing south of Nantucket.
1945, Sept. 19	C	(2)(4)	Overland from Florida; passed just west of New York, moving northeast.
1949, Aug. 29	C	(2)(3)(4)	Travelled overland from northern Florida, crossed center of Maine.
1950, Aug. 20	C	(2)(3)(4)	"Hurricane passed about 200 miles seaward. Torrential rains flooded the streets of Providence; heavy seas pounded the coast." (Providence Journal)

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category(1)</u>	<u>Source of Data</u>	<u>Remarks</u>
1950, Sept. 11	C	(2)(3)(4)	Tide rose to 4.1 ft. above mean sea level at Newport and estimated at 6.4 ft. above mean sea level at Providence. "Tides along Rhode Island shore were held back by prevailing offshore wind. Hurricane passed at sea."
1952, Sept. 1 (Able)	C	(2)(3)(4)	Followed northeasterly track, approximately over New York.
1953, Aug. 15 (Barbara)	C	(2)(3)(4)	Followed path south of Long Island and Nantucket.
1953, Sept. 7 (Carol)	C	(2)(3)(4)	Passed east of Cape Cod heading generally north.
1954, Aug. 31 (Carol)	A	(2)(3)(4)	One of the greatest hurricanes in recent years. Exceeded only by September 1938 hurricane. At Point Judith the tide rose to 11.9 feet above mean sea level along the exposed coast and 10.1 ft. above mean sea level within the Harbor of Refuge.
1954, Sept. 11 (Edna)	B	(2)(3)(4)	At Providence the tide rose to 5.5 feet above mean sea level. This was the second hurricane in 11 days. Hurricane eye split prior to reaching Rhode Island coast.
1954, Oct. 15 (Hazel)	B	(2)(3)(4)	Moderate to heavy rains in New England. Peak gusts reached gale and whole gale force.
1955, Aug. 11 (Connie)	C	(3)(4)	Caused scare in New England and heavy rainfall but no damage. Storm passed southwest of Washington, D. C.

TABLE A-1 (continued)

<u>Date of Hurricane</u>	<u>Category</u> (1)	<u>Source of Data</u>	<u>Remarks</u>
1955, Aug. 18 (Diane)	B	(2)(3)(4)	Passed just south of Long Island and about over Nantucket. Brought record rainfall to many areas of Conn. and Mass; heavy flood damage in river valleys; no important tidal-flood damage along coast.
1955, Sept. 19 (Ione)	C	(3)(4)	Caused scare in New England but no reported damage. Storm turned east and then northeast after passing inland of Cape Hatteras.
1958, Aug. 25 (Daisy)	C	(3)(4)	Caused scare in New England but no damage. South of Nantucket Island the storm turned east and then northeasterly.
1960, July 30 (Brenda)	B	(3)(4)	Storm center crossed New England coast just west of Bridgeport, Conn., and continued into western Connecticut and western Massachusetts. Small boat damage and minor tidal flooding.
1960, Sept. 12 (Donna)	B	(3)(4)	Storm center crossed New England coast near New London, Conn., continued over Worcester, Mass., and into New Hampshire. High winds and tides 4 to 5 feet above normal along southern coast of New England caused moderate tidal flood damage.

NOTES

- (1) The following assigned categories pertain to the effect of a hurricane on the coast of Rhode Island:
 A: Caused severe tidal flooding
 B: Caused damage from wind and rainfall
 (usually accompanied by high seas and moderate tidal flooding).
 C: Threatened the area
- (2) "Hurricanes - Their Nature and History," by I.R. Tannehill (1956).
 (3) Local newspaper accounts, histories, etc.
 (4) Material furnished by U.S. Weather Bureau.

TABLE A-2

SUMMARY OF OTHER NOTABLE STORMS THAT CAUSED HIGH TIDESPOINT JUDITH AREA

<u>Date of Storm</u>	<u>Remarks</u>
1639, March 16	"There was so violent a wind at south-southeast and south as the like was not since we came into this land. It began in the evening, and increased till midnight. It overturned some new strong houses;It tare down fences - people ran out of the houses in the night.... There came such a rain withal, as raised the waters at Connecticut 20 feet above their meadows, etc. (Winthrop's Journal "History of New England, 1630-1649".)
1723, Feb. 24	"Northeast storm of wind and rain, broke and carried away several wharfs; highest tide in 19 years." (Historic storms of New England by Sidney Perley)
1751, Jan 22	"A great gale occurred during which an abundance of buildings were blown down in Warren and Beecher's Cove." (200th Anniversary of Warren, R.I. in Historical Sketch and Program in 1747-1947)
1767, Dec. 14	"From the southward we hear, that the gales . . . did considerable damage to the wharves and shipping at Newport, Stonington, New London, etc. The tides rose higher than had been known for many years in those places . . . Eleven sail bound up the Sound were drove ashore at Stonington . . . It is said the wind, which was at west-southwest was the most violent ever known along that coast." (The Massachusetts Gazette and Boston Weekly Newsletter, No. 3351).
1778, Aug. 12	"Heavy rain all night and day, with strong gale at northeast...one of the most violent gales on record" (Newport). (History of the State of Rhode Island by Samuel Greene Arnold)

TABLE A-2 (cont.)

<u>Date of Storm</u>	<u>Remarks</u>
1869, Feb. 8	"The heaviest in our city (New Bedford) since the gale of 1815 and much damage was done. The rapid rise of the tide brought the vessels up nearly to a level with the wharves." (Daily Mercury, New Bedford, Mass.)
1879, July 16	"There came on a very heavy severe tempest, with the thunder, hale, wind, and a very heavy rain, SE 70°" (Newport). (Weather Diary of Zenas Hammond, Newport, R.I.)
1886, Feb. 11	"Very heavy rain... There was 5 or 6 feet of water in most of the cellars on Cedar Grove Street. The Pond at the Wamsutta Mills overflowed and flooded cellars on that part of Logan Street adjoining" (New Bedford). (Providence Journal, Providence, R.I.)
1888, July 11-12	"Storm became quite severe; all over the city (Providence) there is evidence of its violence; washouts exceed those of any storm since the great September Gale 1869." (The Boston Daily Globe)
1893, Aug. 20	"Trees were blown down, telephone and trolley wires were down. One ship lay broadside on rocks..." (Providence Daily Journal)
1895, Feb. 7	"The tide rose to an unprecedented height and but for the fact that the harbor was completely frozen over, ... damage would have been incalculable. Every wharf was submerged" (New Bedford). (Evening Standard, New Bedford, Mass.)
1933, Jan. 27	"Tide rose to 4.6 feet above mean sea level at Newport."
1936, Oct. 1	Tide rose to 4.3 feet above mean sea level at Newport.

TABLE A-2 (cont.)

<u>Date of Storm</u>	<u>Remarks</u>
1942, March 3	Tide rose to 4.8 feet above mean sea level at Newport.
*1943, March	Tide estimated at 3.5 feet above mean sea level at Newport.
*1944, November 30	Tide rose to 5.5 feet above mean sea level at Newport.
*1945, November	Tide rose to 3.6 feet above mean sea level at Newport.
*1947, March 3	Tide rose to 5.0 feet above mean sea level at Newport.
*1947, October 31	Tide rose to 4.4 feet above mean sea level at Newport.
*1947, November 12	Tide estimated at 4.8 feet above mean sea level at Newport.
1949, Oct. 22	Tide rose to 4.4 feet above mean sea level at Newport.
1950, Aug. 1	Streets were flooded in sections of Providence and nearby cities". The storm center was roughly north-east-southwest and communities in that path received torrential rains which caused severe damage in many cases." (Providence Journal)
1950, Nov. 25-26	At Newport the tide rose to 4.3 feet above mean sea level. Storm struck New York the severest blow. Weather observers in Rhode Island described the storm as "the worst gale since the 1944 hurricane."
1950, Dec. 8	At Newport the tide rose to 4.2 feet above mean sea level.
1951, Feb. 7	At Newport the tide rose to 4.7 feet above mean sea level.

TABLE A-2 (cont.)

<u>Date of Storm</u>	<u>Remarks</u>
1951, Nov. 3	At Newport the tide rose to 4.6 feet above mean sea level.
*1953, February 15	Tide rose to 4.5 feet above mean sea level at Newport.
*1953, April 13	Tide rose to 4.3 feet above mean sea level at Newport.
*1953, October 23	Tide rose to 4.4 feet above mean sea level at Newport.
1953, Nov. 7	At Newport the tide rose to 5.2 feet above mean sea level.
1958, February 16	Northeast storm. Winds at Block Island 60 m.p.h. with gusts to 75 m.p.h. Narragansett police reported "water at highest levels except during hurricane. Waves splashed over wall on Ocean Road". Wind gusts to 60 m.p.h. in Narragansett. Tide rose to an estimated 4.0 feet above mean sea level at Galilee.
1958, March 20	Northeast storm. Winds at Block Island 74 m.p.h. in gusts. Tides rose to an estimated 4.1 feet above mean sea level at Galilee and 2 feet higher along the exposed coast. "High waves pounded shore front communities flooding some low lying areas. Nearly a foot of sand was deposited on Succotash Road when East Matunuck Beach was overtopped."
1958, April 3	Northeast storm. High winds and abnormally high tides. Tide at Galilee rose to an estimated 4.5 feet above mean sea level as a result of the storm coinciding with the springtide. There was minor flooding in the low lying areas of Narragansett Bay. Some damage to beaches along south shore.

TABLE A-2 (cont.)

<u>Date of Storm</u>	<u>Remarks</u>
1958, November 10	Tides 2-3 feet above normal due to new moon and two days of southerly winds. Minor flooding of low lying areas. Tide height at Galilee, 4.4 feet above mean sea level.
1959, December 29	R. I. on edge of severe northeast storm. Winds 50 m.p.h. at Block Island. Tide level at Galilee was 4.6 feet above mean sea level. No damage reported.
1960, January 3	Tides rose 2-3 feet above normal. "Howling gale force winds pushed up angry seas that swept across the South County beaches". Wind speed measured at 60 m.p.h. at Charlestown NAS. Little damage except to beaches at South Kingstown and Narragansett. Tide level at Galilee estimated at 4.1 feet above mean sea level.
1960, February 19	Winds of 75 m.p.h. at Point Judith. Tides in Narragansett Bay $4\frac{1}{2}$ feet above normal with flooding at Newport and Bristol. Tide at Galilee rose to 4.9 feet above mean sea level. No damage except to beaches.
1960, December 21	South and southwest winds with gusts to 43 mph. Tide rose to 4.0 feet above mean sea level at Galilee.

* From monthly maxima recorded at U.S.C.&G.S. gage.

A-3. DESCRIPTIONS

Brief descriptions of type "A" and "B" hurricanes experienced in the Point Judith area as reported in newspaper accounts, or obtained from other records up to 1930, are given below. Subsequent to 1930 numerous and more adequate records are available of storm occurrences, including data on tidal-flood levels, wind velocities, and other storm characteristics.

a. 15 August 1635. (type "A"). From "Of Plymouth Plantation, 1620-1647," by William Bradford.

"This year the 14 or 15 of August (being Saturday) was such a mighty storm of wind and rain, as none living in these parts either English or Indian, ever saw, being like (for the time it continued) to those Haurricanes and Tuffons that writers make mention of in the Indies. It began in the morning, a little before day, and grew not by degrees, but came with violence in the beginning to the great amazement of many. It blew down sundry 211 houses, and uncovered others; divers vessels were lost at sea, and more in danger. It caused the sea to swell (to southward of this place) about 20 feet right up and down, and made many of the Indians to climb into trees for their safety; it took off the board roof of a house which belonged to this plantation at Manamet, and floated it to another place, the posts still standing in the ground; and if it had continued long without the shifting of the wind, it is like it would have drowned some part of the country. It blew down many, many hundred thousands trees turning up the stronger by the roots, breaking the higher pine trees off in the middle, and the tall young oaks and walnut trees of good bigness were wound like a withe, very strange and fearful to behold. It began in the southeast and parted toward the south and east, and veered sundry ways; but the greatest force of it here was from the former quarters. It continued not (in the extreme) above 5 or 6 hours, but the violence began to abate. The signs and marks of it will remain this 100 years in these parts where it was sorest. The moon suffered a great eclipse the second night after it."

The following excerpt is quoted from Governor John Winthrop's "Journal" 1630 to 1649:

"***About eight of the clock the wind came about to Northwest very strong, and, it being then about high water, by nine the tide was fallen about 3 feet. Then it began to flow again about one hour, and rose about 2 or 3 feet, which was conceived to be, that the sea was grown so high abroad

with the Northeast wind, that, meeting with the ebb, it forced it back again.

"This tempest was not so far as Cape Sable, but to the south more violent, and made a double tide all that coast.

"The tide rose at Narragansett fourteen feet higher than ordinary and drowned 8 Indians flying from their wigwams."

b. 3 August 1638. (type "A"). From Governor John Winthrop's "Journal", 1630 to 1649.

"In the night was a very great tempest or hiracano at Southwest which drave a ship on ground at Charlestown, and brake down the windmill there, and did much other damage. It flowed twice in 6 hours, and about Narragansett it raised the tide 14 or 15 feet above the ordinary spring tides, upright."

c. 30 October 1723. (type "A"). From "The Boston Weekly News Letter", No. 1033. From Thursday, November 14, to Thursday, November 27, 1723.

"Rhode Island - On Wednesday last we had here a very great Southeast storm of wind and rain, and a very high tide, a foot higher than ever was known before, which has broken and carried away several of our wharves, and drove some vessels ashore from their anchors, and has done considerable damage in warehouses and cellars, to dry goods and other merchandise; the loss is computed to some thousand pounds."

d. 24 October 1761. (type "A"). From "The Boston News Letter", No. 2991. Thursday, October 29, 1761.

"There was a hard gale of wind which brought the highest tide into the harbor of Providence in Rhode Island that hath been known in the memory of man, and carried away the great or Weybosset Bridge. Five or six vessels were drove ashore and greatly damaged, and it being high water there, it got into the stores and cellars and damaged sugars, etc. to the amount of 12 or 15000 pounds their currency. On both roads East and West, so far as we have heard, the roofs of houses, tops of barns, and fences, have been blown down, and it is said thousands of trees have been torn up by the roots by the violence of the above storm, and we fear we shall hear melancholy accounts of damage done at sea."

The following excerpt is quoted from "Memoirs of Rhode Island 1636-1783" by Henry Bull.

"From the Newport Mercury of October 27, 1761 - On Friday last came on a terrible storm from the North-east, which continued increasing with a very heavy rain, and did not abate till after 2 in the morning. The violence of the wind broke off part of the steeple of Trinity Church. Several persons sustained considerable loss in their sugar, salt, etc. by the prodigious rise of tide, which flowed into their stores and cellars. Many of the ships in the harbor were driven ashore from the wharves and their moorings, but without any considerable damage except to two ships. Sad havoc has been made with the lumber and wood on the wharves, great quantities of fence blown down and numbers of trees torn up by the roots. People hardly thought themselves safe in their own houses, for a more violent storm has scarce ever been known here."

e. 19-20 October 1770. (type "A"). From "History of the State of Rhode Island" by Samuel Greene Arnold.

"A violent storm again blew down a part of the spire of Trinity Church at Newport, and caused an immense loss of life and property along the coast. Newport suffered very severely in this gale."

f. 19 September 1787. (type "B"). From the diary of William Wheeler in "Black Rock, Seaport of Old Fairfield, Connecticut 1699-1870."

"Line storm. A mill at Stamford carried off whole and Norwalk bridge floted."

g. 19 August 1788. (type "B"). From "History of the State of Rhode Island" by Samuel Greene Arnold.

"Heavy rain all night and day, with strong gale at northeast...one of the most violent gales on record" (Newport).

h. 9-10 October 1804. (type "B"). From "The Connecticut Courant" (October 17).

"The partial and summary accounts which have been received from the neighboring towns, though they afford no particulars of the effects of the late gale, sufficiently evince the widespread destruction which has been experienced by it. In all most every direction the fruit and other trees have been generally blown down, the fences

destroyed and much damage done by the heavy rain, which fell during the storm.¹⁰

1. 22-23 September 1815. (type "A"). From "Historic Storms of New England" by Sidney Parley.

*The storm began at three o'clock on the morning of Friday, the twenty-second, when the wind was at the north-east, and rain fell copiously until sunrise. Shortly after, the clouds partly broke away, and fair weather seemed about to return. During the forenoon, however, the clouds became thicker, the sky darkened, and in some sections of New England rain fell to a considerable amount. In the afternoon the wind blew with increased force, and rain continued to fall in small quantities. Through the night the wind was moderate, and there was a slight fall of rain, but before sunrise the next morning the wind again became violent having changed to the east in the night, and about nine o'clock it shifted to the southeast, and continued to increase in force until it blew so fiercely that buildings, fences, trees, vessels along the exposed sections of the coast, and all kinds of movable things, were swept away before it. But little rain fell during the tornado where it was the fiercest. The wind did not blow steadily, but came in gusts, and continued its work of destruction until noon, when it changed to the southwest, after which it quickly subsided. Then a little more rain fell, but before night pleasant weather had come.

*The force of the gale was principally and most severely felt in Narragansett Bay in Rhode Island. The wind swept the bay and Providence suffered from its effects more than any other place. From ten to half-past eleven o'clock it blew a hurricane. About the wharves and lower part of the town generally confusion reigned. High water was about half-past eleven o'clock in the forenoon, and the wind brought in the tide ten or twelve feet above the height of the usual spring tides, and seven and a half feet higher than ever known before, overflowing and inundating streets and wharves. The vessels there were driven from their moorings in the stream and fastenings at the wharves, with terrible impetuosity, toward the great bridge that connected the two parts of the town. The gigantic structure was swept away without giving a moment's check to the vessels' progress, and they passed on to the head of the basin, not halting until they were high up on the bank. All the vessels were driven ashore, or totally destroyed. There were wrecked in the cove four ships, nine brigs, seven schooners and fifteen sloops. After the storm they lay

high and dry, five or six feet above high-water mark, in the streets and gardens of the town. One sloop stood upright in Pleasant Street before the door of a Mr. Webb, and a ship was in the garden of General Lippett. Nine of the vessels that were driven ashore were successfully launched again, but more than thirty were totally lost.

"The storm raged with increasing violence, and the water was rapidly rising and deluging the lower parts of the town. Wharves were being washed away, stores and other buildings on them were about to leave their foundations, and the water surged around the houses of the people who resided in the lower sections. Stores and dwelling houses were seen to reel and totter for a few moments, and then plunge into the deluge. A moment later their fragments were blended with the wrecks of vessels, some of which were on their sides, that were passing with great rapidity and irresistible impetuosity on the current to the head of the cove, to join the wrecks already on the land.

"On the west side of the river the water rose nearly to the tops of the lower windows of the houses, and people were removing, in boats and scows, from their dangerous situation. Most of the stores and other buildings were destroyed and the fragments carried into the cove above the bridge. On the east side the water rushed impetuously through Weybosset Street, which was the principal thoroughfare, nearly a yard in depth, turbulently carrying along with it boats, masts, bales of cotton, etc., with almost resistless force. It seemed as if that portion of the town was doomed. The store on Bowen's wharf just below where the bridge had stood still maintained its place, though much injured, but all the stores below, on the east side, were either carried away or so much damaged that they were in a great measure useless. Several dwelling-houses on Eddy's point were carried off, leaving not a vestige behind. In Westminster Street, the water was from six to eight feet above the pavements. All the space which but an hour or two before had been occupied by valuable wharves and stores filled with goods, and the river that had been crowded with vessels, were now one wide waste of water raging and furious. Along the higher portion of land were heaped together lumber, wrecks of buildings and vessels of every description, carriages, and bales of cotton, mingled with household furniture, coffee, soap, candles, grain, flour and other kinds of merchandise.

"Five hundred buildings in all, large and small, were destroyed in this gale and flood, which, with other property that was lost, were valued at fifteen hundred thousand dollars.

"Beside those persons who were wounded and maimed, many valuable citizens were carried with their houses into the water, and others were crushed to death between the planks and the vessels as the latter dashed through the great bridge. No one knows how many human lives were lost in Providence, nor how many cattle were drowned. No business but that in connection with the storm could be done for some time, the streets having first to be cleared, and then buildings, bridges, and wharves rebuilt."

"Bristol - At Bristol, a short distance from Providence down Narragansett Bay, all the vessels were driven a great distance in on the land, and considerably injured. There the tide rose seven feet higher than it was ever known to rise before, and the wharves were completely swept away. A long row of brick stores on one of the wharves, with their contents, which were very valuable, were carried away. A great many trees were also blown down, and much other damage done."

j. 3 September 1821. (type "A"). From "The Newport Mercury",
Newport, Rhode Island.

"Providence - During the severe gale on Monday night, the Brig Commerce got loose from her fastening at one of the wharves near the Market, and came with a tremendous crash against the bridge, slightly injuring some small craft which lay in her course, and the railing of the bridge. Considerable damage was done to trees, etc. in this vicinity by the gale; a part of Butts Rope Walk West Side, and an unfinished building at the North end, were blown down; the tower erected for the accommodation of the wild beasts (our annual commencement visitors) in the yard of Wessons Hotel, was also demolished but its inmates were secured from elopement.

"Much apprehension was entertained for several hours of disasters by flood as well as wind, and there were many waking eyes and throbbing hearts; but happily the tide and the residents within the range of the devastations by the never-to-be forgotten flood of 1815 retired to their beds about midnight, providently delivered from a visitation fearfully anticipated, and dreaded equally with fire brands, arrows and death. The tide did not rise much above its usual bounds."

k. 2-4 October 1841. (type "B"). From "The Daily Mercury", New Bedford, Massachusetts.

"Severe northeasterly storm commenced here on Saturday night and continued on Sunday and yesterday with but little abatement. Some damage was done to the shipping and many chimneys were blown down. A large unfinished stone building was blown entirely down, and one or two small houses destroyed."

l. 29-30 October 1866. (type "B"). From "The Providence Daily Journal", Providence, Rhode Island.

"A gale of un wonted severity has prevailed in this vicinity since last evening. Shortly before 3:00 this morning rain commenced falling and continued until about noon. The wind has made much mischief with signs, awnings, chimneys, etc., and there has been some commotion among the vessels in the harbor.

"The heavy blow between 12:00 and 1:00 this afternoon did considerable damage to the shipping in the port, although the loss was not so serious as at one time seemed eminent.

"The gale stripped off part of the roof of the Stove foundry on Cove Street. A building being constructed on Harrison Street was badly wrecked. Two dwelling houses on Smith's Hill belonging to Rhode Island Locomotive Works were prostrated and in falling crushed the side of the third building. These were ready for the plasters. The windows were not in.

"The tide was forced by the wind to an unprecedented height and the water flowed into West Water and Dyer Streets filling cellars and doing much damage. The water also overflowed the wharves on the east side and penetrated the cellars. Steam fire engines were brought into requisition to assist in abating the tide.

"Those malicious people who thought there was a leak somewhere about the \$30,000 City Hall on Market Square will not be surprised to learn that the flood tide found it and rushed in so freely that the water was several inches deep in the offices in the basement; there is grave reason to fear that the leak remains, against another flash time on the Narragansett. The gale at Narragansett was tremendous. The New St. Peters Free Chapel (Episcopal) was utterly demolished. Other buildings suffered."

m. 8 September 1869. (type "A"). From "The Great September Gale of 1869 in Providence and Vicinity" by Tillinghast and Mason of Providence.

"Our city has again been visited by a flood and gale, outrivaling in fury and destructiveness the terrible storm of September 1815. On Wednesday morning, September 8th, the sky was overcast, and occasionally a slight shower fell over the city; in the forenoon the clouds were dispelled somewhat and the sun came out for a short time. About noon the wind sprung up quite fresh from the southeast, blowing up large masses of dark clouds. Between two and three o'clock, p.m., it commenced to rain quite freely, the wind, in the meantime, blowing still heavier. At four p.m., the wind was blowing a perfect hurricane and the rain coming down in torrents. The combined power and fury of the elements were beyond all description. It seemed as if nothing could withstand them. The water in the harbor rose to a great height, and poured over the wharves and into the streets, in the lower portion of the city, with appalling swiftness - at one time rising two feet in twenty minutes. Mighty trees bent and bowed before the tempest, some of them being torn up by the roots, while others were snapped off like rotten twigs. Boards, bricks, shingles, broken boughs, portions of gates and fences, shutters, signs, and fragments of all kinds filled the air. Massive buildings rocked like toys, roofs of tons in weight were lifted and carried rods away, or torn into minute pieces. Huge strips of tin and metal were torn from places where they had been securely nailed, and blown like sheets of papers, for long distances. Steeples rocked and fell; huge buildings were crushed in like egg shells; vessels were swept like chips upon the shore; dwellings were overturned and carriages blown along the street like feathers. For the first time since the advent of telegraphy in this city we were without a single 'tap' from outside 'barbarians', not a wire of either the Western Union or Franklin Lines being in working order. If the violence of the wind had continued for half an hour longer, it is probable that the waters of the harbor would have united with those of the Cove, in the very busiest portions of the city. The rise was at the rate of a foot every ten minutes. The hurricane abated somewhat in its fury about 5:45; and very soon afterwards the water rapidly receded, leaving South Water and Dyer Streets completely covered with the wrecks of the gale. The water poured into the Press Office in great volumes, putting out the fires in the engine room and submerging the press room to the depth of eighteen inches. An editorial in the Press of Thursday says: 'The water mark in the room where

we write is eighteen inches from the floor and all around are indications of a great flood, beaten in history only by Noah's celebrated deluge and the Great Gale of 1815'.

"The Steam Fire Engines of the city were busy all night in pumping out the cellars near the wharves, but several days elapsed before the water was entirely cleared out.

"Numbers of our citizens who experienced the gale of 1815, say the gale of 1869 was heavier while it lasted than that of its destructive predecessor. It is almost impossible to compute the damage done to property on land and sea, but in our own State it must amount to hundreds of thousands of dollars.

"Bristol - The gale Wednesday was very disastrous at this place. The wind was from the southeast and very terrific. The tide rose very rapidly. At 5½ o'clock it was six feet above high water mark. Had the wind held southeast two hours longer the damage by water would have been immense. Over two hundred of the ornamental trees which adorned the streets were blown down and others were destroyed. Most of the public buildings were more or less injured.

"All the wharves were damaged, some of them very seriously, especially the long wharf and the wharf belonging to the Fall River Iron Works Company. Nearly all of the sail boats, fishing boats and fishing smacks in the harbor, were either driven ashore and wrecked or sunk at their moorings. No lives were lost. Several persons were injured."

"Warren - A large number of valuable shade trees were uprooted in various parts of the town. A portion of the new cotton factory was unroofed.

"Throughout the state, but more especially along the coast, the damage by the gale was equally disastrous, and those who experienced it will not readily forget the September Gale of 1869."

From: The Narragansett Weekly, Westerly, Rhode Island, September 16, 1869

"Narragansett Pier - A letter from the Pier says the wave which rolled in there was the heaviest ever known, but that the damage was not excessive considering the

violence of the storm. Fences and chimneys are blown down, and many windows forced in. The Episcopal Church recently completed is in ruins."

n. 22-23 October 1878. (type "A"). From "The Evening Standard", New Bedford, Massachusetts.

"The storm yesterday afternoon and last night was very severe, the rain falling in torrents, but there was little damage in this vicinity. Several vessels and boats got adrift at the docks, but trifling damage was done, some of the wharves were flooded. The last train from Providence was prevented from reaching Fall River on account of a washout near Cole's River. The velocity of the wind was 50 miles an hour. The storm originated in the Gulf of Mexico on Monday morning."

o. 10 December 1878. (type "B"). From "The Providence Daily Journal", Providence, Rhode Island.

"Yesterday was a rainy day and the wind blew mightily from the southeast in fitful gusts. Toward evening the wind increased in fury and power. The wind did not decrease in volume or strength until 8:00 p.m. and the rain fell as rapidly as during the day.

"About 5:30 p.m. when the wind was at its height the cigar factory which was on supports preparatory to being moved was blown down (\$3,000 damage). A floating bath house above India Bridge was blown from its mooring. A ship broke loose. Cellars flooded, some up to 8 inches.

"The water in the river (Providence River) rose very high, higher than before this year. Fortunately the wind went down about an hour before high water and danger was averted. This is the second time this year in which the gale ceased an hour or so before high tide. Water washed over the Dorrance Street wharf. Dyer Street cellars got a little water."

p. 18 August 1879. (type "B"). From "Stamford Herald", (Weekly) August 20.

"---From a test made at Waterside the rainfall during the late storm was found to be 8 inches. On Monday from 7:00 a.m. to 7:00 p.m. a little over $4\frac{1}{2}$ inches fell.

"A more soaking continuous and persistent rainstorm we have seldom experienced in August... corn has suffered under the infliction of so much rain and wind..."

q. 10 September 1889. (type "B"). From "The Greenwich News", Friday, September 13.

"The furious northeaster which has been raging along the Atlantic Coast for the past few days is one of the severest storms known in this vicinity for years, and one of the most destructive to property. Ever since Tuesday when the storm reached here from the Atlantic, it has blown a gale, mostly from the northeast, accompanied nearly all of the time by rain.

"The greatest force of the storm has been felt along the coastline...small craft along the shore have suffered severely...

"Greenwich has suffered comparatively little from the storm. A few trees have been blown down and the roads have been damaged more or less, but beyond this there was scarcely any damage done. On Tuesday there was a very high tide in the harbor and at one time part of the steamboat dock was under water... the only loss reported along the shore are one or two row boats."

"The schooner Annie Jacobs from New Haven... was beached on Mansuring Island during the storm Tuesday night."

From: "The Westerly Narragansett Weekly", September 19.

"The high surf last week drew crowds of sight-seers to Watch Hill from Westerly, Stonington and Mystic. It was a grand sight to see the big waves come rolling in, until apparently they were about to swamp the land. Not much damage was done except the destruction of the Peninsula house"

r. 23-24 August 1893. (type "A"). From "The Providence Daily Journal", Providence, Rhode Island.

"The herald of the storm in this city was a heavy bank of mist, which came in from the sea early in the evening. In the meantime the storm from the southeast came rapidly along. It struck New York about 1:00 p.m. and the wind blew a gale. The disturbance was felt along the wires and shortly after 4:00 p.m. they ceased to act entirely along the line of the storm.

"At 11:00 p.m. the rain began to fall in the city. It was shortly before daybreak when the storm put in its appearance.

"At 5:00 a.m. the storm was in full possession of the town and the rain fell in blinding sheets. The houses shook with the force of the blast. The big limbs were torn from the sturdy elms. The rain-fall practically ceased at 7:00 yesterday morning, with .55 inch being recorded at Hope Reservoir. A maximum velocity of 28 (?) m.p.h. was registered by the aerometer between the hours of 6:00 and 7:00 a.m. The greatest depth of rain for any one hour was .20 inch between 5:00 and 6:00 a.m.

"At Pawtuxet when it was time for low tide yesterday morning, no low tide appeared. In fact it was said to be higher than usual."

s. 29 August 1893. (type "B"). From "The Columbian Weekly Register", (New Haven) Thursday, August 31.

"Early this morning the wind blew 50 miles an hour, breaking all previous records . . . Late last night the barometer recorded 29.98, but it was only 29.38 early this morning . . .

t. 9-10 September 1896. (type "B"). From "The Providence Daily Journal", Providence, Rhode Island.

"The storm which began yesterday morning, came un-heralded, as all northeast storms do. The barometer had been falling since the night before. The wind increased in severity during the day and by noon was blowing a gale along the shore. In Providence the wind held steadily northeast and reached a maximum of 23 m.p.h. This was probably much less fierce than was experienced in more level and exposed districts. This maximum was reached at the hour from 6:00 to 7:00 Thursday morning. Washouts occurred in many localities. Most of these were small and not productive of any great damage. The total rain-fall as registered by the Hope Reservoir gauge was 3.16 inches. The greatest amount of rain falling in one hour was from 4:50 to 5:50 p.m. Wednesday when .75 inch was recorded. For a portion of that hour rain fell at a rate of $1\frac{1}{2}$ inch per hour but the torrents of rain were limited to something like half an hour, and during the remainder of the storm the rainfall was much lighter.

"The storm was a most peculiar one, for while the wind was off shore the sea was constantly increasing, and at nightfall it dashed in upon the rocky shore and the spray being thrown fully 25 feet in the air.

"Beach row, which lies along the ocean front, and is occupied by the Pavillion, the bathing house and a number of business offices was early in the evening partly submerged by water. At 9:00 last night the wind was blowing at the rate of 60 m.p.h.

"At Block Island the storm was considered the severest on record at this season of the year. Late in the afternoon the wind velocity was recorded at 76 m.p.h. with no signs of abating.

"At Point Judith the wind reached 80 m.p.h. A number of vessels were lost."

u. 16 September 1903. (type "B"). From "The Bridgeport Daily Standard", September 17.

"Very strong winds and rain unroofed houses, felled or uprooted trees.

"... a casual survey of the damage along the waterfront shows that it will run into the thousands...

"At the Bridgeport Yacht Club in the Black Rock harbor there was damage galore, and but for the active work of the yachtsmen there would have been several fine yachts totally wrecked.

"Although the waves were very high the water did comparatively little damage...no water ever reached the roadway although everybody was completely drenched with the spray which rose in a long continuous, heavy white cloud the whole length of the sea wall."

From: "The Westerly Daily Sun", September 17.

"New Haven

"Southwest Connecticut came within the radius of the storm which swept up the Atlantic coast and the fury of the elements did greater damage than any disturbance of a like character in the month of September for a great many years. Trees were ripped up, telephone and telegraph wires were torn down . . . At many places small craft were dashed to pieces on the shore. Crop damage was severe."

From: "The Daily Advocate", Stamford, September 16.

"The storm which is raging all over this section struck Stamford with a vengeance at noon today and inside of an hour it had shaped itself into what old-timers say, is the swiftest easterly storm experienced for twenty years or more...

"On the east shore of Shippan, the storm was felt with great severity, and the same is true of Sound Beach where there are a number of summer cottages near the shore.

"The wind blew great gusts...rain fell in veritable sheets. On exposed corners this was particularly noticeable, the pavements being under a constant wash of water...

v. 15 September 1904. (type "B"). From "The Providence Journal", Providence, Rhode Island.

"One of the most memorable storms in the history of the city and certainly as long as the Weather Bureau has been running at City Hall broke yesterday morning about 7:00, and for intensity it has seldom been equalled. It was not long but was sudden and severe. The rainfall for the length of time was of a surprisingly large volume. The wind was about 50 m.p.h., the temperature took a sudden fall after the storm and there were other phenomena connected with the storm.

w. 13 November 1904. (type "B"). From "New Haven Evening Register", November 14.

"Here in New Haven the wind in yesterday's gale blew as high as 50 miles an hour. Many telephone and telegram wires were prostrated and there was some light wreckage about the harbor..."

"Telephone lines were blown down, trees uprooted, streets gullied out, cellars flooded and a large amount of stock in down town stores was seriously spoiled. Little damage was done to shipping as storm warnings had been put out.

"About 6:30 a.m. the down pour and high wind came. Houses rocked. The streets on College Hill had ditches washed out in the center 3 feet deep. The rainfall amounted to $1\frac{1}{2}$ inch for the hour between 7:00 and 8:00 a.m. The average force of the wind was 26 m.p.h. but gusts

reached 50 m.p.h. Many trees were destroyed or damaged. According to the City Engineer records at Providence the precipitation from the commencement of the storm was 3.78 inches; barometer 29.44.

"Block Island - The wind shifted to northwest and reached a velocity of 84 m.p.h. Several small boats went ashore on the breakwater.

"Newport was this week visited by a wind and rain storm which, for intensity and the amount of damage done, has not been equalled for many years. The gale was of comparatively brief duration but in a few hours it accomplished considerable damage. All day Wednesday it was stormy with considerable rain and the storm continued during the night. About 6:00 Thursday morning there was a decided change. The wind shifted suddenly from the southeast and commenced to blow with great fury. At the same time the rain continued to fall in large quantities. Trees were uprooted, fences blown down, cellars flooded, etc."

x. 1 October 1920. (type "B"). From "The Day", New London.

"The gale that swept the east last night and early this morning did a large amount of damage in Connecticut, principally to telephone, telegraph and trolley systems, caused the wrecking of 3 barges near this city and brought loss to rural districts through the destruction of late crops and fruit.

".

"New London was visited by an unusually severe wind and rain storm Thursday. The gale which began early in the day developed into a gale Thursday night, the wind blowing with a velocity of about 80 miles an hour when it reached its height about midnight. The damage was considerable but not serious. Telephone and electric wires were blown down, limbs were ripped off trees and in one or two instances trees were uprooted. Shipping on the Sound was delayed."

y. 26 August 1924. (type "B"). From "The Providence Journal", Providence, Rhode Island.

"Lives were imperilled, vessels blown ashore in Narragansett Bay, hundreds of trees uprooted or damaged, telephone and power service disrupted, and fruit, corn and other crops partially ruined yesterday in the severest summer wind and rainstorm that has visited Providence in

many years. Damages totalling hundreds of thousands of dollars was caused.

"The northeaster, coming up the Atlantic coast from the tropics, hit Rhode Island with almost hurricane force, reaching a maximum of 50 m.p.h. at the Weather Bureau Station here, and raged along the Bay and coast territory at an estimated 75 to 80 m.p.h. rate. Waves in sheltered Narragansett Bay were shipped to a height that mariners of 30 years experience say they have never seen equalled in these waters.

"The shores of the Bay are littered with small boats which were torn loose from their moorings by the wind and blown aground. More than 5,000 telephones in Rhode Island were put out of commission and more trouble was experienced with power by the Narragansett Electric Lighting Company than in any storm except that of last March in the history of the Company. Many sections were without lights last night.

"The wind raged throughout Rhode Island with tropical force from 11:00 in the morning until 2:00 in the afternoon. It was the third heaviest days rainfall in the history of the local weather bureau station. A total of 3.70 inches fell since the start of the storm Monday and of this amount 2.76 inches fell yesterday.

"After raining almost continuously since shortly after 9:00 Monday evening, the storm subsided in mid-afternoon yesterday and the skies cleared a few hours later. An abnormally low barometer reading of 29 was registered at the height of the storm. A 50 m.p.h. velocity was registered from the North at 2:00. The wind shifted into the northwest a little later.

"Boats were broken up on rocks and sunk and cottages and stores along the shore at Narragansett Pier were flooded during the storm, which was accompanied by the worst surf experienced in years. Inland at Narragansett Pier, Peace Dale and Wakefield the wind did heavy damage to trees and shrubs on a number of estates, *****.

"The tropical storm that was central south of Cape Hatteras Monday night moved rapidly North-Northeastward, and its center was off the eastern Maine coast Tuesday night. It was attended by strong shifting gales and general rains along the coast from the Carolines northward. The highest wind velocity reported was 72 m.p.h. from northwest of Cape Hatteras".

z. 2 October 1929. (type "B"). From "New Haven Journal-Courier", October 3.

"Damage which will probably total thousands of dollars was done yesterday along west shore in Milford by the lashing northeaster which swept northward from the Caribbean...its ferocity had been largely spent by the time it had reached the shores of Long Island Sound...

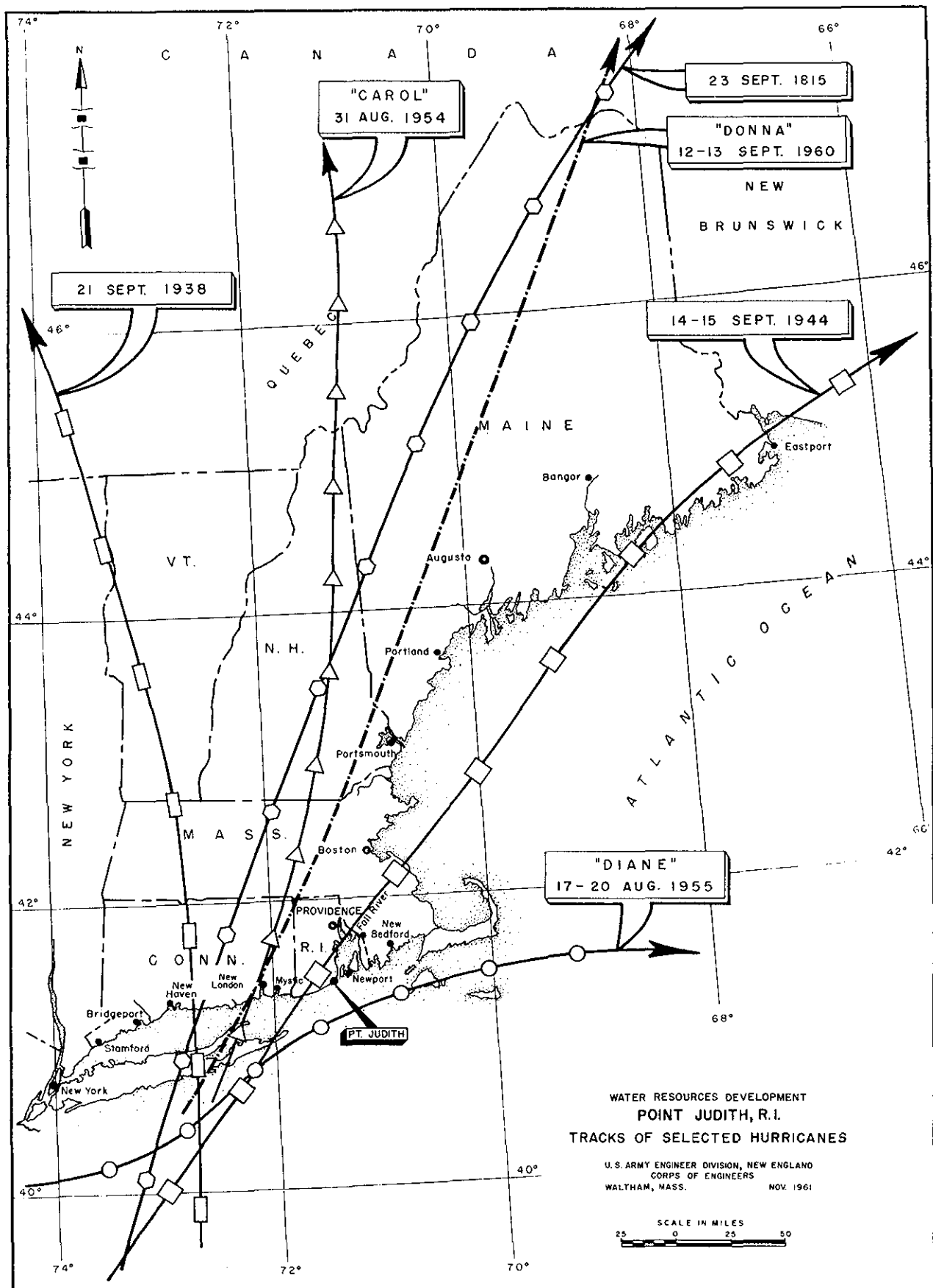
"The largest damage reported from along the shore yesterday came from Silver Beach in Milford where the strong northeasterly and easterly gale created waves at the high tide hour this morning which tossed one cottage off its foundations...

"The water overflowed the trolley tracks and in some places covered the Milford shore road to a depth of two feet...the storm concentrated its fury on the Milford shore...

"High tides came near flooding street car tracks where they pass close to the water's edge on the shore runs, it was said, but no delays were brought about by this cause.

A-4. HURRICANE TRACKS

The tracks of four notable hurricanes causing tidal flooding and serious damages along the Rhode Island coast, namely, those of September 1815, September 1938, September 1944, and August 1954 are shown on Plate A-1. The path of Hurricane Donna, September 1960, the most recent hurricane to strike New England, and Hurricane Diane, August 1955, which brought record rainfall to many areas in southern New England, are also shown on the plate.



APPENDIX B
HYDROLOGY AND HYDRAULICS

APPENDIX B

APPENDIX B

HYDROLOGY AND HYDRAULICS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
B-1	INTRODUCTION	B-1
	HYDROLOGY	
B-2	Temperature and Precipitation	B-1
B-3	Streamflow	B-1
B-4	Drainage Areas	B-3
B-5	Hurricane Rainfall	B-3
B-6	Runoff	B-5
B-7	Hurricane Winds	B-6
B-8	Hurricane Barometric Pressures	B-8
	HYDRAULICS	
B-9	Hurricane or Storm-Tide Flood Levels	B-8
B-10	Elevation Frequency	B-10
B-11	Standard Project Hurricane Derivation	B-15
B-12	Design Hurricane Tidal Flood Level	B-16
B-13	Design Wave Heights	B-16
B-14	Wave Runup and Overtopping	B-17
B-15	Erosion by Hurricanes	B-17
B-16	Flow through Breachway	B-18
B-17	Velocities in Navigation Opening	B-19
B-18	Modified Flood Levels	B-19
	a. General	B-19
	b. Effect of Breachway Control Structure	B-19
	c. Effect of Fresh Water Runoff	B-19

TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
B-1	Monthly Temperature	B-2
B-2	Monthly Precipitation	B-2
B-3	Hurricane Rainfalls	B-4
B-4	Maximum Winds	B-7
B-5	Minimum Barometric Pressures	B-9
B-6	Tidal Elevations vs. Frequency Data Hurricanes and Severe Storms, Sand Hill Cove and Matunuck	B-11 & B-12
B-7	Tidal Elevations vs. Frequency Data Hurricanes and Severe Storms, Newport and Galilee-Jerusalem	B-13 & B-14
B-8	Shore Erosion by Storm Waves	B-18

PLATES

<u>Number</u>	<u>Title</u>
B-1	Location Map for Hurricane Flood Levels Profile, Connecticut-Rhode Island State Line to Point Judith, Rhode Island
B-2	Hurricane Flood Levels Profile, Connecticut-Rhode Island State Line to Point Judith, Rhode Island
B-3	Tide Curves, Hurricanes of 1938 and 1954, at Matunuck
B-4	Tide Curves, Hurricanes of 1938 and 1954, at Entrance to the Breachway, Point Judith Harbor of Refuge

PLATES (cont.)

<u>Number</u>	<u>Title</u>
B-5	Frequency of Tidal Flooding from Hurricanes and Storms at Matunuck, Galilee and Jerusalem (Pt. Judith Pond).
B-6	Area and Capacity Curves, (Pt. Judith Pond, Potter Pond and Upper Pond.
B-7	Effect of Hurricane Protection Plan in Reducing Flood Levels - Point Judith Pond.

APPENDIX B

HYDROLOGY AND HYDRAULICS

INTRODUCTION

B-1. This Appendix presents data to supplement the sections of the main report relating to hydrology and hydraulics. It includes summaries of temperature and precipitation data, and data on wind velocities, rainfall and barometric pressures during a hurricane. The computations of tidal flood levels leading to the selection of the design storm tide, the analysis of wave heights, runup and overtopping, rainfall, runoff, and navigation current velocity studies are also included.

HYDROLOGY

B-2. TEMPERATURE AND PRECIPITATION

The variable and temperate climate of the Point Judith area is influenced by several meteorological factors which produce extremes of temperature and precipitation. The area lies in the path of the "prevailing westerlies" and the cyclonic disturbances that cross the country from the west and southwest. It is also exposed to coastal storms that move up the Atlantic seaboard, some of which are of tropical origin. Pertinent temperature and precipitation data were taken from the United States Weather Bureau Station at Kingston, Rhode Island, 8 miles north of Point Judith. The monthly mean, maximum and minimum records of temperature and precipitation are based on the period from 1889-1956 and are summarized in Tables B-1 and B-2.

B-3. STREAMFLOW

The Saugatucket River is the principal drainage artery in the upper portion of the Point Judith drainage basin. It flows in a southerly direction and is subject to tidal action to the mill dam at Main Street in the center of Wakefield. There are no streamflow records available.

TABLE B-1

MONTHLY TEMPERATUREKINGSTON, RHODE ISLAND

<u>Degrees Fahrenheit</u>				<u>Degrees Fahrenheit</u>			
<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
Jan.	28.1	63	-23(1)	July	69.4	98	38
Feb.	27.9	64	-22	Aug.	68.1	99(2)	33
Mar.	35.6	82	-4	Sept.	62.0	95	26
Apr.	44.8	85	8	Oct.	52.1	87	13
May	55.0	93	25	Nov.	41.3	76	4
June	63.8	96	30	Dec.	31.2	65	-17
				Annual	48.3		

(1) 11 Jan 1942

(2) 9 Aug 1949

TABLE B-2

MONTHLY PRECIPITATIONKINGSTON, RHODE ISLAND

<u>Inches</u>				<u>Inches</u>			
<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Month</u>	<u>Mean</u>	<u>Maximum</u>	<u>Minimum</u>
Jan.	4.57	11.43	0.83	July	3.21	11.75	.43
Feb.	4.03	9.44	.67	Aug.	4.43	13.56(2)	.79
Mar.	4.66	9.67	.23	Sept.	3.61	12.66	.35
Apr.	4.33	9.70	.72	Oct.	3.81	12.05	.27
May	3.82	8.95	.67	Nov.	4.43	10.25	.41
June	3.21	7.42	.47	Dec.	4.44	11.59	.83
				Annual	48.51	72.22(3)	31.76(4)

(1) 1915

(2) 1952

(3) 1898

(4) 1943

B-4. DRAINAGE AREAS

The drainage area for the project can be divided into three parts which are described as follows:

a. Saugatucket River Area. The drainage area of the Saugatucket River is rectangular in shape, approximately 6 miles long and three miles wide, containing 16.7 square miles. The river originates in the swampy area of North Kingstown, Rhode Island, and flows in a general southerly direction for about $6\frac{1}{2}$ miles to Silver Spring Cove of Upper Pond. Approximately 5 percent of the area is residential, 30 percent is in swamps with many mill dams and reservoirs and about 65 percent is forested, which amply regulates the flow into the Upper Pond.

b. Local Area. This area begins at Upper Pond and encompasses 9.7 square miles bordering the ponds, and runoff flows directly into Upper Pond, Point Judith Pond and Potter Pond. Since the area is composed of flat brush land, swamps, forests and scattered ponds, only 30 percent of the area, or three square miles is considered to be effective in contributing to runoff.

c. Pond Area. This area consists of three interconnecting ponds; Potter Pond, Point Judith Pond, and Upper Pond, with pond areas at mean sea level of 421, 1,329 and 150 acres, respectively.

B-5. HURRICANE RAINFALL

Among the greatest rainfalls associated with hurricanes in New England are those recorded for Connie and Diane in August 1955. Hurricane Connie, 11-15 August, caused rainfall varying from about four to six inches over southern New England and ended a period of drought. A week later, Hurricane Diane, 17-20 August, brought rainfall of 16 to 20 inches over Massachusetts. Although the Point Judith area did not receive excessive rainfall in either of these storms, Hurricane Diane did cause a record fall of 13.1 inches in 55 hours (4.1 inches in 6 hours) at West Mansfield, Massachusetts, 42 miles northeast of the Point Judith area.

Values of rainfall at a number of New England locations, which may be considered indicative of amounts that can occur in the Point Judith area, are shown on Table B-3. The total rainfalls associated with recent hurricanes that have caused tidal flooding in the Point Judith area are: 2.3 inches in September 1938, 4.4 inches in September 1944, and 2.9 inches in August 1954 (Hurricane Carol).

TABLE B-3

HURRICANE RAINFALLSSOUTHERN NEW ENGLAND LOCATIONS

<u>Location</u>	<u>Accumulated Rainfall in Inches</u>			
	<u>6-hr.</u>	<u>12-hr.</u>	<u>24-hr.</u>	<u>Storm Total</u>
<u>17-20 August 1955 - Hurricane Diane</u>				
New Bedford, Mass.	2.2	2.6	2.7	3.9 (35 hr.)
Westfield, Mass.	7.9	10.9	18.2	19.8 (48 hr.)
Mendon, Mass.	6.4	6.7	9.9	13.8 (56 hr.)
Mansfield, Mass.	4.1	5.8	8.5	13.0 (55 hr.)
Providence, R.I.	2.9	4.2	5.5	6.1 (46 hr.)
Kingston, R. I.	1.9	2.1	2.5	3.1 (44 hr.)
<u>11-15 August 1955 - Hurricane Connie</u>				
New Bedford, Mass.	2.4	4.0	4.2	4.3 (43 hr.)
Norfolk, Conn.	2.3	3.0	5.4	8.7 (78 hr.)
Block Island, R.I.	2.4	2.8	3.4	3.7 (33 hr.)
Kingston, R. I.	4.0	4.8	5.3	5.7 (34 hr.)
<u>11 September 1954 - Hurricane Edna</u>				
New Bedford, Mass.	2.8	3.3	--	3.4 (15 hr.)
Woonsocket, R. I.	4.8	5.8	--	6.3 (15 hr.)
Providence, R. I.	3.3	3.9	--	4.4 (15 hr.)
Kingston, R. I.	4.2	4.8	--	5.5 (15 hr.)
<u>30-31 August 1954 - Hurricane Carol</u>				
New Bedford, Mass.	1.3	1.9	--	1.9 (13 hr.)
Mendon, Mass.	4.3	4.9	--	5.1 (15 hr.)
Providence, R. I.	1.9	2.7	--	2.8 (13 hr.)
Kingston, R. I.	1.9	2.8	--	2.9 (13 hr.)
<u>12-15 September 1944</u>				
New Bedford, Mass.	1.8	1.9	2.1	3.4 (53 hr.)
New Haven, Conn.	3.9	4.0	4.0	8.5 (57 hr.)
Newington, Conn.	5.3	5.3	5.4	7.7 (54 hr.)
Portsmouth, R. I.	1.3	1.4	2.7	4.3 (40 hr.)
Kingston, R. I.	1.8	1.9	1.9	4.4 (74 hr.)
<u>17-21 September 1938</u>				
New Bedford, Mass.	0.5	0.9	1.1	2.2 --
Barre, Mass.	--	--	--	17.0 --
Springfield, Mass.	3.2	4.4	6.3	10.4 (95 hr.)
Providence, R.I.	0.6	1.0	1.1	3.1 (73 hr.)
Kingston, R. I.	0.6	0.7	1.0	2.3 (73 hr.)

B-6. RUNOFF

There are no streamflow records for the Saugatucket River. The nearest drainage area comparable to that of the Saugatucket River, with gaging station, is that of the Wading River. The Wading River gaging stations are located at West Mansfield and Norton, Massachusetts, approximately 40 miles north of Point Judith, with drainage areas of 19.2 and 42.4 square miles. The gaging station at West Mansfield has only been in operation since October 1953, while the Norton gage has been in operation since June 1925. Since the river above each gaging stations had the same runoff per square mile, the Norton gaging station record with the longer period was used. The following tabulation shows the data pertinent to the Wading and Saugatucket Rivers. The data indicate that the rates of runoff from the Saugatucket River is equivalent to or less than that of the Wading River.

<u>Description</u>	<u>Wading River at Norton, Mass.</u>	<u>Saugatucket River at mouth</u>
Drainage area (sq. mi.)	42.4	16.7
Length of stream (miles)	14.2	7.6
Average stream gradient	.00164	.00172
Maximum length of area (miles)	13.6	6.6
Maximum width of area (miles)	5.1	4.0
Areas of lakes and ponds (sq. mi.)	0.8	0.5

The topography in the above areas is low and flat, with numerous lakes, swamps and forests which are conducive to low runoff and a relatively long period of concentration.

The total storm rainfall of 13.05 inches experienced at Mansfield, Massachusetts, as a result of Hurricane Diane in August 1955, resulted in a flow of 1,172 c.f.s. (27.6 c.f.s. per square mile) in the Wading River at Norton, whereas in a number of other New England river basins flows of over 500 c.f.s. per square mile were caused by nearly similar rainfalls during this same storm. Hurricane Diane caused no tidal-flood surge in the Point Judith area.

The runoff in the Wading River at Norton from rainfall antecedent and coincident with recent hurricanes which caused tidal-flooding in the Point Judith area and the runoff with a 10-year frequency are listed below.

<u>Hurricane</u>	<u>Runoff</u> (c.f.s.)	<u>Runoff</u> (c.f.s./sq. mi.)
September 1938	180	4.25
September 1944	137	3.23
August 1954 (Carol)	27	0.64
September 1960 (Donna)	26	0.61
10-year runoff	690	16.30

The effect of runoff on modified flood levels in the Point Judith Pond area are discussed in paragraph B-18.

The runoff from the local area surrounding the Potter Pond, Point Judith Pond and Upper Pond, which has a relatively sluggish drainage area, under conditions of a design hurricane, has been predicated on a 10-year, 4-hour rainfall of 2.9 inches and the assumption that 15 percent of this rainfall over an effective three square miles of the drainage area, would contribute runoff to the above ponds. See paragraph B-4.

The runoff over the pond areas is also based on a 10-year, 4-hour rainfall of 2.9 inches with 100 percent runoff and has been used coincident with the peak of a design hurricane.

B-7. HURRICANE WINDS

The maximum wind velocity in New England during the 1938 hurricane was a recorded gust of 186 miles per hour at the Blue Hill Observatory in Milton, Massachusetts, 60 miles north of Point Judith, which is the maximum gust recorded in any hurricane in New England. A sustained 5-minute wind of 121 miles per hour was recorded at the Blue Hill station. At other locations in southern New England, sustained 5-minute velocities ranged from 38 to 87 miles per hour.

Sustained 5-minute velocities of 33 to 85 miles per hour were recorded at a number of locations along the New England coast during the hurricane of 14 September 1944. An estimated gust of 109 miles per hour occurred at Hartford, Connecticut.

In southern New England, during Hurricane "Carol", 31 August 1954, gusts of 125 and 135 miles per hour were experienced at Milton, Massachusetts, and Block Island, Rhode Island, respectively. Sustained 1-minute velocities ranging from 38 to 98 miles per hour were registered.

The recorded wind velocities at locations in southern New England for the three great hurricanes are summarized in Table B-4.

TABLE B-4

MAXIMUM WINDSHURRICANES OF 1938, 1944 AND 1954 IN NEW ENGLAND

<u>Location</u>	<u>Velocity in Miles Per Hour</u>			
	<u>Sustained 5-Min.</u>	<u>Sustained 1-Min.</u>	<u>Maximum Gust</u>	<u>Direction</u>
<u>Hurricane of 21 September 1938</u>				
Hartford, Conn.	46	-	59	NE
New Haven, Conn.	38	-	46	NE
Providence, R. I.	87	95	125(est.)	SW
Block Island, R. I.	82	-	91	SE
Milton, Mass. (Blue Hill Observatory)	121	-	186	S
<u>Hurricane of 14 September 1944</u>				
New Haven, Conn.	33	38	65	N to NE
Hartford, Conn.	50	62	109(est.)	N
Block Island, R. I.	82	88	100+(est.)	SE
Chatham, Mass.	-	85	100(est.)	-
Point Judith, R. I.	85(est.)	90(est.)	-	SSE
Milton, Mass. (Blue Hill Observatory)	67	77	-	-
Providence, R. I.	43(1)	49(1)	90(1)	SE
<u>Hurricane of 31 August 1954, "Carol"</u>				
Bridgeport, Conn.	-	-	60	-
New Haven, Conn.	-	38	65	N
Hartford, Conn.	-	56	64	NE
Block Island, R. I.	-	98	135	SE
Milton, Mass. (Blue Hill Observatory)	-	93	125	SE
Providence, R. I.	-	90(1)	105(1)	ESE

(1) At Hillsgrove, R. I.

B-8. HURRICANE BAROMETRIC PRESSURES

The center or "eye" of the 1938 hurricane crossed the Connecticut coast line about 15 miles east of New Haven and 50 miles west of Point Judith at about 3:30 P.M., E.S.T., on 21 September and then proceeded northerly at a rate of 50 to 60 miles per hour. The lowest observed pressure was 28.04 inches of mercury at Hartford, Connecticut. Block Island, Rhode Island, recorded a low of 28.66 inches of mercury.

The eye of the hurricane of 14 September 1944 passed directly over Point Judith. The minimum recorded barometric pressure was 28.31 inches of mercury.

Hurricane "Carol", 31 August 1954, crossed the south shore of Connecticut in the vicinity of New London, about 30 miles west of Point Judith, at 10:30 A.M., E.S.T. A low of 28.20 inches of mercury was recorded at Storrs, Connecticut. Block Island, Rhode Island, recorded a low of 28.50 inches of mercury. The eye at the closest point was 30 miles west of Point Judith.

The minimum pressures recorded at a number of New England locations during these three great hurricanes of the past 20 years are summarized in Table B-5.

HYDRAULICS

B-9. HURRICANE OR STORM-TIDE FLOOD LEVELS

The heights of tidal flooding experienced at a number of locations in the Point Judith area during Hurricane "Carol" (1954) were obtained in the course of the field damage-survey work for the southern New England coastline. The elevation of these flood levels, referred to mean sea level, were then determined by a field level party. This information was supplemented by material on high water levels collected by the Corps of Engineers after the September 1938 hurricane. Based on this data, profiles have been prepared of the 1938 and 1954 tidal flood elevations between Willets Point, New York, at the western end of Long Island Sound, and Wareham, Massachusetts, at the eastern end of Buzzards Bay. A map and profile for the Rhode Island coastline between the Connecticut State line on the west and the entrance to Narragansett Bay on the east have been prepared (see Plates B-1 and B-2). At Point Judith (Matunuck) general levels of 12.3 feet, m.s.l. in 1938 and 11.9 feet, m.s.l. in 1954 are indicated. The levels along the shore within the Harbor of Refuge were 10.5 feet above mean sea level for 1938 and 10.1 feet above mean sea level for 1954, a reduction in each case of 1.8 feet. This reduction is attributable to the breakwaters forming the Harbor of Refuge. The still water levels within Point Judith Pond for 1954 varied from 9.1 feet above

TABLE B-5

MINIMUM BAROMETRIC PRESSURESHURRICANES OF 1938, 1944 AND 1954 IN NEW ENGLAND

<u>Location</u>	<u>Time</u> (E.S.T.)	<u>Barometric Pressure</u> (Inches of Mercury)
<u>Hurricane of 21 September 1938</u>		
Hartford, Conn.	4:17 P.M.	28.04
New Haven, Conn.	3:30 P.M.	28.11
Block Island, R. I.	3:05 P.M.	28.66
Milton, Mass. (Blue Hill Observatory)	-	29.01
Providence, R. I.	3:45 P.M.	28.90
<u>Hurricane of 14 September 1944</u>		
Hartford, Conn.	9:50 P.M.	28.94
New Haven, Conn.	8:50 P.M.	28.86
Westerly, R. I.	9:40 P.M.	28.43
Block Island, R. I.	10:09 P.M.	28.34
Point Judith, R. I.	10:20 P.M.	28.31
Milton, Mass. (Blue Hill Observatory)	-	-
Providence, R. I.	11:15 P.M.	28.51
<u>Hurricane of 31 August 1954</u>		
New Haven, Conn.	9:10 A.M.	28.77
New London, Conn.	10:00 A.M.	28.26
Storrs, Conn.	11:00 A.M.	28.20
Block Island, R. I.	-	28.5
Milton, Mass. (Blue Hill Observatory)	-	29.9
Providence, R. I.	11:12 A.M.	28.79

mean sea level at the Breachway to 10.9 feet above mean sea level at the northern limit of the Pond. This illustrates the effect of wind setup in raising the levels at the north end of the Pond. Tide curves for the 1938 and 1954 hurricanes are shown on Plates B-3 and B-4.

B-10. ELEVATION FREQUENCY

In the preparation of tidal elevation-frequency data for Point Judith, consideration was given to similar data which had been prepared for Newport Harbor, Rhode Island. The United States Coast and Geodetic Survey has maintained a recording tide gage in the Newport Harbor area from September 1930 to the present time; also, there is good high water mark elevation data for the 1938 and August 1954 hurricanes in this area. However, Newport Harbor is located within Narragansett Bay while Point Judith is located on the Atlantic Ocean (Block Island Sound). High water mark elevation data indicates that the stillwater tidal-flood elevations for the 1938 and August 1954 hurricanes at Point Judith (Matunuck) were 1.5 and 2.1 feet higher, respectively, than the corresponding elevations at Newport Harbor. The maximum stillwater tidal elevation, which might be expected on an average of once a year at Point Judith (Matunuck) is about 1.7 feet higher than the corresponding elevation at Newport Harbor. These relatively higher tidal elevations at Point Judith (Matunuck) have generally been confirmed by Beach Erosion Board model studies of February 1958 as due to wave setup. The tidal elevation-frequency curve for Point Judith (Matunuck) is based on (1) observed tidal flood elevations for the 1938 and August 1954 hurricanes, (2) Beach Erosion Board model test data of February 1958, and (3) Newport Harbor and Point Judith Pond (Galilee) tidal elevation data stage related to Point Judith (Matunuck). The tidal elevation-frequency curve for Point Judith Pond (Galilee and Jerusalem) is based on (1) observed tidal flood elevations for the 1938 and August 1954 hurricanes (2) Galilee tide gage record (C. of E., NED gage period of record October 1956 to date) and (3) Newport Harbor tidal elevation data stage related to Point Judith Pond (Galilee and Jerusalem). Tidal elevation-frequency data for Point Judith (Matunuck) and Point Judith Pond (Galilee and Jerusalem) is shown on Tables B-6 and B-7. The Point Judith frequency curves (see Plate B-5) represent composite curves based on the 326-year period, 1635-1960 and the 146-year period, 1815-1960, that influence the upper portion of the curve and the 30-year period, 1931-1960, for which there is a continuous tide gage record that determines the lower portion of the curves.

TABLE B-6

TIDAL ELEVATIONS VS FREQUENCY DATA

HURRICANES AND SEVERE STORMS

SAND HILL COVE, NARRAGANSETT, RHODE ISLAND
AND
MATUNUCK, SOUTH KINGSTOWN, RHODE ISLAND

Hurricane or Storm	Maximum Tidal Elevation at Sand Hill Cove, Narragansett, RI(2)		Maximum Tidal Elevation at Matunuck, So. Kingstown, RI(9)		Percent Chance of Occurrence in any one year (1)		
	(ft., m.s.l.)		(ft., m.s.l.)		(1635- 1960)	(1815- 1960)	(1931- 1960)
hurricane, 3 Aug. 1638	12.2+	(3)	14.3+		0.15		
hurricane, 15 Aug. 1635	11.5+	(3)	13.5+		0.46		
hurricane, 21 Sept 1938	10.5	(4)	12.3	(10)		0.34	1.7
hurricane, 31 Aug. 1954	10.1	(4)	11.9	(10)		1.03	5.0
hurricane, 23 Sept 1815	9.5+	(5)	11.2+			1.71	
hurricane, 14 Sept 1944	6.5	(6)	8.3				8.3
storm, 30 Nov. 1944	5.4		7.2				11.7
hurricane, 12 Sept 1960	5.3	(7)	7.1				15.0
storm, 7 Nov. 1953	5.1	(6)	6.9				18.3
storm, 19 Feb. 1960	5.1	(8)	6.9				21.7
storm, 3 Mar. 1947	4.9	(6)	6.7				25.0
storm, 29 Dec. 1959	4.8	(8)	6.6				28.3
storm, 3 Mar. 1942	4.7		6.5				31.7
storm, 12 Nov. 1947	4.7		6.5				35.0
storm, 14 Feb. 1960	4.7	(8)	6.5				38.3
storm, 7 Feb. 1951	4.6		6.4				41.7
storm, 3 Apr. 1958	4.6		6.4				45.0
storm, 27 Jan. 1933	4.5		6.3				48.3
storm, 3 Nov. 1951	4.5		6.3				51.7
storm, 10 Nov. 1958	4.5	(8)	6.3				55.0
storm, 15 Feb. 1953	4.4		6.2				58.3
storm, 2 Dec. 1942	4.3		6.1				61.7
storm, 31 Oct. 1947	4.3		6.1				65.0
storm, 22 Oct. 1949	4.3		6.1				68.3
storm, 23 Oct. 1953	4.3		6.1				71.7
storm, 16 Oct. 1955	4.3		6.1				75.0
storm, 1 Oct. 1936	4.2		6.0				78.3
storm, 25 Nov. 1950	4.2		6.0				81.7
storm, 13 Apr. 1953	4.2		6.0				85.0
storm, 20 Mar. 1958	4.2		6.0				88.3
storm, 3 Jan. 1960	4.2		6.0				91.7
storm, 21 Dec. 1960	4.1	(8)	5.9				95.0
storm, 12 Dec. 1944	4.05		5.85				98.3
storm, 8 Dec. 1950	4.05		5.85				100.0

TIDAL ELEVATIONS VS FREQUENCY DATA

HURRICANES AND SEVERE STORMS

SAND HILL COVE, NARRAGANSETT, RHODE ISLAND
AND
MATUNUCK, SOUTH KINGSTOWN, RHODE ISLAND

TABLE B-6 (cont.)

- (1) Calculated plotting position
 $P = \frac{100 (M-0.5)}{Y}$ where
P = percent chance of occurrence in any one year.
M = number of the event.
Y = number of years of record.
- (2) Based on record of U.S.C. & G.S. recording tide gage located at Constellation Dock, Coasters Harbor Island, Newport, Rhode Island, stage related to Sand Hill Cove, Narragansett, Rhode Island, except as noted.
- (3) Based on historical account and stage related from Newport, Rhode Island.
- (4) Based on high water mark elevations at Sand Hill Cove Area, Narragansett, Rhode Island.
- (5) Based on high water mark elevation at Providence, Rhode Island, stage related to Sand Hill Cove, Narragansett, Rhode Island.
- (6) Estimated by U.S.C. & G.S. at Constellation Dock, Coasters Harbor Island, Newport, Rhode Island and stage related to Sand Hill Cove, Narragansett, Rhode Island.
- (7) Based on record of Corps of Engineers, New England Division staff gage, located at United States Coast Guard Point Judith Life Boat Station Dock, Galilee, Narragansett, Rhode Island, stage related to Sand Hill Cove, Narragansett, Rhode Island.
- (8) Based on record of Corps of Engineers, New England Division recording tide gage, located at United States Coast Guard Point Judith Life Boat Station Dock, Galilee, Narragansett, Rhode Island, stage related to Sand Hill Cove, Narragansett, Rhode Island.
- (9) Based on Sand Hill Cove, Narragansett, Rhode Island tidal elevation data, stage related to Matunuck, South Kingstown, Rhode Island and Beach Erosion Board Model studies data of February 1958, except as noted.
- (10) Based on high water mark elevations at Matunuck Area, South Kingstown, Rhode Island.

TABLE B-7

TIDAL ELEVATIONS VS. FREQUENCY DATAHURRICANES AND SEVERE STORMSNEWPORT HARBOR, NEWPORT, RHODE ISLANDANDGALILEE AND JERUSALEM, POINT JUDITH POND, NARRAGANSETT, R. I.

<u>Hurricane or Storm</u>	Maximum Tidal Elevation at Newport Harbor, R. I. (ft., msl)	Maximum Tidal Elev. at Galilee and Jerusalem, Pt. Judith Pd. Narra., R.I. (8) (ft., msl)	Percent Chance of Occurrence in any One Yr. at Galilee and Jerusalem, Pt. Judith Pd., Narra. R. I. (1)		
			(1635- 1960)	(1815- 1960)	(1931- 1960)
rrricane, 3 Aug. 1638	12.3+ (2)	11.1+	0.15		
rrricane, 15 Aug. 1635	11.6+ (2)	10.5+	0.46		
rrricane, 21 Sept. 1938	10.8 (3)	9.5 (9)		0.34	1.7
rrricane, 31 Aug. 1954	9.8 (3)	9.1 (9)		1.03	5.0
rrricane, 23 Sept. 1815	9.6+ (4)	8.7+		1.71	
rrricane, 14 Sept. 1944	6.6 (5)	6.1			8.3
orm, 30 Nov. 1944	5.5 (6)	5.2			11.7
rrricane, 12 Sept. 1960	5.4 (6)	5.1 (10)			15.0
orm, 7 Nov. 1953	5.2 (5)	5.0			18.3
orm, 19 Feb. 1960	4.9 (6)	4.9 (11)			21.7
orm, 3 Mar. 1947	5.0 (5)	4.8			25.0
orm, 3 Mar. 1942	4.8 (6)	4.6			28.3
orm, 12 Nov. 1947	4.8 (6)	4.6			31.7
orm, 29 Dec. 1959	4.7 (6)	4.6 (11)			35.0
orm, 7 Feb. 1951	4.7 (6)	4.5			38.3
orm, 3 Apr. 1958	4.7 (6)	4.5			41.7
orm, 14 Feb. 1960	4.8 (6)	4.5 (11)			45.0
orm, 27 Jan. 1933	4.6 (6)	4.4			48.3
orm, 3 Nov. 1951	4.6 (6)	4.4			51.7
orm, 10 Nov. 1958	4.5 (6)	4.4 (11)			55.0
orm, 15 Feb. 1953	4.5 (6)	4.3			58.3

TABLE B-7 (cont)

Hurricane or Storm		Maximum Tidal Elevation at Newport Harbor, R. I.	Maximum Tidal Elev. at Galilee and Jerusalem, Pt. Judith Pd. Narra., R.I. (8)	Percent Chance of Occurrence in any One Yr. at Galilee and Jerusalem, Pt. Judith Pd., Narra. R. I. (1)		
		(ft. msl)	(ft. msl)	(1635- 1960)	(1815- 1960)	(1931- 1960)
Storm,	2 Dec. 1942	4.4 (6)	4.2			61.7
Storm,	31 Oct. 1947	4.4 (6)	4.2			65.0
Storm,	22 Oct. 1949	4.4 (6)	4.2			68.3
Storm,	23 Oct. 1953	4.4 (6)	4.2			71.7
Storm,	16 Oct. 1955	4.4 (6)	4.2			75.0
Storm,	1 Oct. 1936	4.3 (6)	4.1			78.3
Storm,	25 Nov. 1950	4.3 (6)	4.1			81.7
Storm,	13 Apr. 1953	4.3 (6)	4.1			85.0
Storm,	20 Mar. 1958	4.3 (6)	4.1			88.3
Storm,	3 Jan. 1960	4.3 (7)	4.1			91.7
Storm,	21 Dec. 1960	4.2 (7)	4.0 (11)			95.0
Storm,	12 Dec. 1944	4.2 (6)	3.95			98.3
Storm,	8 Dec. 1950	4.2 (6)	3.95			100.0

(1) Calculated plotting position

$$\frac{100 (M - 0.5)}{Y}$$

P = $\frac{100 (M - 0.5)}{Y}$ where

P = percent chance of occurrence in any one year.

M = number of the event.

Y = number of years of record.

(2) Estimated from historical account and stage related from Providence, Rhode Island.

(3) Based on high water marks at Newport, Rhode Island.

(4) Based on high water mark elevation at Providence, Rhode Island, stage related to Newport, Rhode Island.

(5) Estimated by U.S.C. & G.S.

(6) Based on record of U.S.C. & G.S. recording tide gage located at Constellation Dock, Coasters Harbor Island, Newport, Rhode Island.

(7) Based on record of Corps of Engineers, New England Division recording tide gage, located at United States Coast Guard Castle Hill Life Boat Station, Newport, Rhode Island.

(8) Based on Newport Harbor tidal elev. data, stage related to Galilee and Jerusalem, Pt. Judith Pd., Narragansett, Rhode Island, except as noted.

(9) Based on high water mark elevations at Galilee and Jerusalem, Pt. Judith Pond, Narragansett, Rhode Island.

(10) Based on record of Corps of Engineers, NED staff gage, located at United States Coast Guard Pt. Judith Life Boat Station Dock, Galilee, Narragansett, R.I.

(11) Based on record of Corps of Engineers, NED recording tide gage, located at United States Coast Guard Pt. Judith Life Boat Station Dock, Galilee, Narragansett, R. I.

B-11. STANDARD PROJECT HURRICANE DERIVATION

The U. S. Weather Bureau has provided the wind fields for use of the Beach Erosion Board, the Texas A & M Research Foundation, and the U. S. Army Engineer Division, New England, for the determination of tide elevation in Narragansett Bay for the September 1944 hurricane transposed. This furnishes the basis for determination of the corresponding tide elevation at Point Judith located close to the mouth of Narragansett Bay.

The September 1944 hurricane transposed to a hypothetical path due north over water from Cape Hatteras, North Carolina, with an assumed forward speed of 40 knots and the center 49 nautical miles west of the project area produces wind and surge most critical to the area. A modification of the Texas A & M surge determination of the transposed 1944 hurricane in Narragansett Bay at Newport, Rhode Island and the 1938 hurricane observed surge at Newport and Point Judith, respectively, is the basis for calculation of the surge at Point Judith that approximates a Standard Project Hurricane surge. This approximation of the Standard Project Hurricane surge is about 1.33 times the observed 1938 hurricane surge at Point Judith derived as follows:

	<u>Point Judith (Matunuck)</u>	<u>Newport Harbor</u>
Observed 1938 Hurricane Tide Levels ft., m.s.l. (stillwater level)	12.3	10.8
Predicted Tide, ft.	<u>2.0</u>	<u>2.4</u>
Observed 1938 Hurricane Surge, ft.	10.3	8.4

Newport Harbor, Rhode Island

Adopted Design Surge Height, ft. (1)	11.2
Ratio: $\frac{\text{Adopted Design Storm Surge}}{\text{Observed 1938 Surge}} = \frac{11.2}{8.4} =$	1.33

Point Judith (Matunuck), Rhode Island

Standard Project Hurricane Surge, ft. = $1.33 \times 10.3 =$	13.7
Mean Spring High Water, ft., m.s.l.	<u>2.3</u>
Standard Project Flood Elevation, ft., m.s.l. (stillwater level)	16.0

- (1) January 1960 Design Memorandum No. 4, Hurricane Tidal Hydraulics, Fox Point Hurricane Barrier, Providence River, Providence, R. I.

Even though Point Judith is only 14 miles southwest of Newport, the difference in the surge heights is quite marked due largely to the wave set-up factor (see Par. B-10). Point Judith is on the exposed coast and is subject to heavy wave action, while Newport is relatively protected just inside Narragansett Bay.

The Standard Project Hurricane flood level within the Harbor of Refuge at the Breachway was calculated to be 13.0 feet above mean sea level or 3 feet lower than along the exposed coast.

B-12. DESIGN HURRICANE TIDAL FLOOD LEVEL

The cost of plans to provide protection against flood levels accompanying the Standard Project Hurricane exceeded the estimated recurring flood damages. All plans of protection to these extreme and rare levels were dropped from further consideration. Studies of protective works, using the still water level of the flood of record (21 Sept. 1938) as a basis of design, showed that economical structures could be provided to prevent about 90% of the estimated recurring damages of the 1938 hurricane in the Point Judith Pond area. The selected design still water elevations of 12.5 and 10.5 feet above mean sea level, outside and inside the Harbor of Refuge, respectively, represent the maximum levels reached by hurricane flood waters in a 323-year period. At the Breachway, where wave set-up is smaller, the design still water level would be 9.5 feet above mean sea level.

The plan of protection would reduce the design hurricane tidal flood levels within the Point Judith Pond area by 3 to 4 feet.

B-13. DESIGN WAVE HEIGHTS

Design wave heights at Point Judith have been determined from a wave with a 33-foot significant height and a 13.5 second period generated by a 84-mile per hour southeast wind from the Continental Shelf to one-half mile off shore. Shoreward of this location the wave heights are less as the depth of water becomes shallower.

The wave heights at the toe of the protective works have been calculated on the premise that the maximum wave height that can be sustained is 0.78 times the depth of water at the toe. These heights varied from approximately 10 feet along the exposed coast at Matunuck-Jerusalem and 8 feet within the Harbor of Refuge at Galilee - Sand Hill Cove. The wave heights would, theoretically, become zero on the berm of the structure when the berm elevation is at design still water level. Most of the wave energy would be dissipated on the beach slopes, but there would be some uprush of water on the berm.

The wave heights in the entrance channel at the Breachway where the control structure is located are estimated at 7 feet. The wave energy that would be carried through the 150-foot opening would be dissipated rapidly by diffraction and refraction in the relatively broad and shallow areas of Point Judith Pond.

Wave heights within the Pond would be about 2 feet in the Galilee-Jerusalem area immediately behind the protective works and would regenerate to about 4 feet in the northern portion, near Wakefield. These heights represent a reduction of 5 feet at the southern portion and no change at the northern portion, as a direct result of hurricane protection improvements.

B-14. WAVE RUNUP AND OVERTOPPING

Runup values were calculated for numerous locations on the protective structure by the method outlined in "Wave Runup on Composite Slopes" by Thorndike Saville, Jr., using wave heights ranging up to the significant wave height of the design storm. It was determined that the most critical waves were those which break at the toe of the structure (where $H_b = 0.78d_b$). It was found that the larger ocean waves would break farther out on the gently sloping ocean bottom, and energy would be dissipated over the increased distance to the structure and runup would be less. Due to the flat slopes of the structure, smaller waves breaking part way up these slopes also result in less runup than those breaking at the toe.

The structures were designed so that there would be no overtopping of the protective barrier by wave runup.

Water transport by waves running through the 150-foot wide navigation opening and minor overtopping at the lower levels of the Breachway Control Structure would have negligible effect in raising the water level within Point Judith Pond.

B-15. EROSION BY HURRICANES

An important consideration in the design of the protective beach is an estimate of the maximum erosion which can be expected during a hurricane. Erosion of beaches between Hyannis Port and Chatham along the south shore of Cape Cod was observed by the Massachusetts Department of Public Works following the September 1944 hurricane. The wave action riding in on top of the surge in this severe hurricane (maximum of record) based on 25 selected locations spaced over 25 miles of shore, caused cutback averaging 25 feet with a maximum of 40 feet. Erosion of 10 cubic yards per foot of beach occurred at several locations.

The Cape God observations were compared with data collected by the Beach Erosion Board and reported in Miscellaneous Paper No. 1-59, dated April 1959. The following table summarizes the information for the mean high water level at a number of locations.

TABLE B-8
SHORE EROSION BY STORM WAVES

<u>Storm and Location</u>	<u>No. of Profiles</u>	<u>Landward Retreat of Contour (feet)</u>	
		<u>Average</u>	<u>Maximum</u>
New Jersey Storm of Nov. 1953	20	65	100
Florida West Coast Hurricane of September 1950	29	35	greater than 100
Virginia Beach Storm of October 1948	-	100	-
Long Island Hurricane of September 1938	8	40	122
Louisiana Coast Hurricane "Audrey" June 1957	9	125	-

B-16. FLOW THROUGH BREACHWAY

Flow through the Breachway was computed using the formula:

$$Q = CA\sqrt{2gH} \quad \text{in which}$$

Q = flow in c.f.s.

C = coefficient of discharge

A = area of waterway opening in square feet

g = acceleration of gravity = 32.2 feet/sec²

H = head causing flow through the opening in feet

The coefficient, C, was estimated to be 0.6 based on data given in U. S. G. S. Circular No. 284, "Computation of Peak Discharge at Contractions." It is believed that this value of the coefficient of discharge reasonably reflects the contraction and losses which would occur during flow through the Breachway.

B-17. VELOCITIES IN NAVIGATION OPENING

To determine the effect of the Breachway control structure on currents and tidal levels during normal tides, a mean tide with a range of 3.1 feet was routed through the opening. The change in the tidal range in Point Judith Pond was negligible. The average currents through the Breachway were increased about 0.2 of a knot, reading a maximum of 3.1 knots.

B-18. MODIFIED FLOOD LEVELS

a. General. Flow through the Breachway Control Structure, fresh water inflow from rainfall runoff, and the overtopping of the barriers by breaking waves would combine to produce modified tidal flood levels (see Plate B-6) behind the protection during future hurricanes. An analysis was made of each of these factors to determine their combined effect on future flood levels (see Plate B-7).

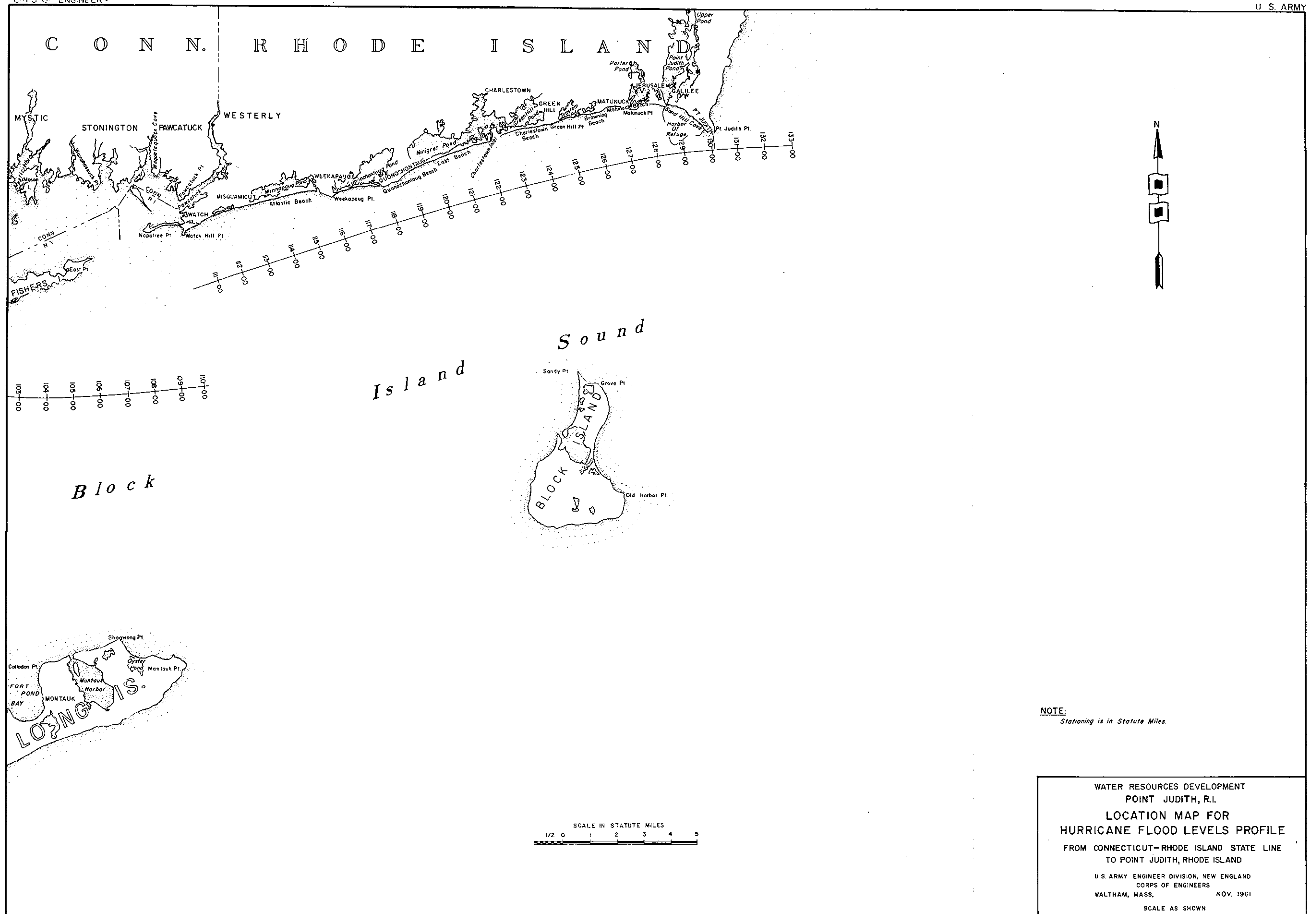
b. Effect of Breachway Control Structure. After the construction of the barriers and dikes the main access of tidal flood waters to the Point Judith and Potter Pond areas would be through the Breachway Control Structure. The amount of inflow through the Breachway is dependant largely on the height and duration of the hurricane tide. While the 1954 hurricane tide was slightly lower than the 1938 tide its longer duration would permit more water to flow through the Breachway and thus raise the ponds to a higher elevation. The 1954 hurricane tide was therefore used in the evaluation of the effectiveness of the Breachway Control Structure.

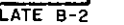
The hurricane tide at the entrance to the Breachway was routed through the opening using the relationship described in paragraph B-16.

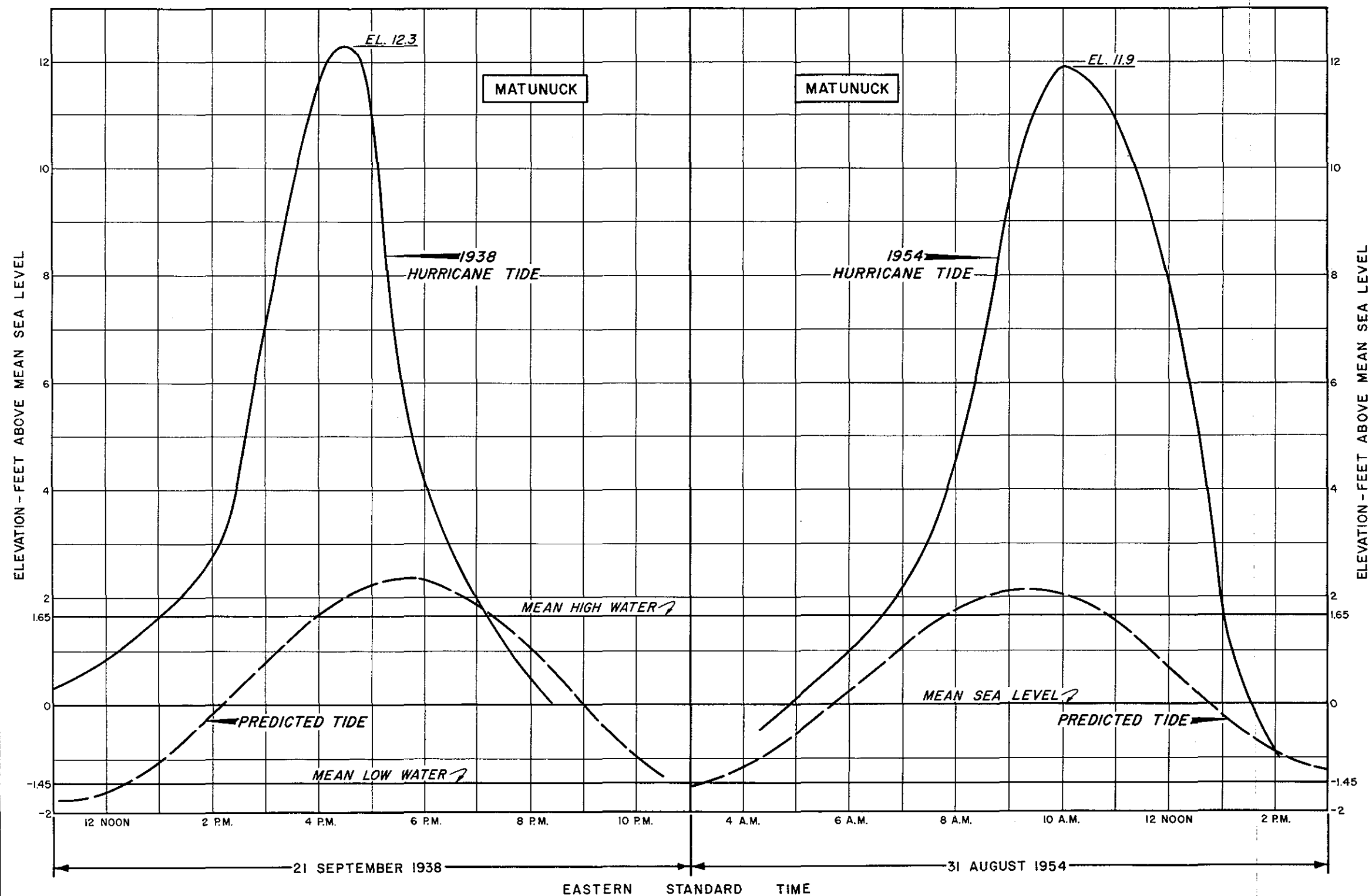
c. Effect of Fresh Water Runoff. The fresh water runoff which occurred with the hurricanes listed in paragraph B-6, with the exception of the 10-year runoff, originated from rainfalls having less than a two-year frequency.

Based on antecedent runoff and a design runoff from a 10-year 4-hour rainfall frequency, the total runoff would be approximately 1800 c.f.s. into the Point Judith area. This

design runoff was assumed concurrent with the design still water level of 9.5 feet above mean sea level at the entrance to the Breachway. Graphical routings through the Breachway indicated that the fresh water runoff would raise the pool elevation less than one-tenth of a foot in the Point Judith area.







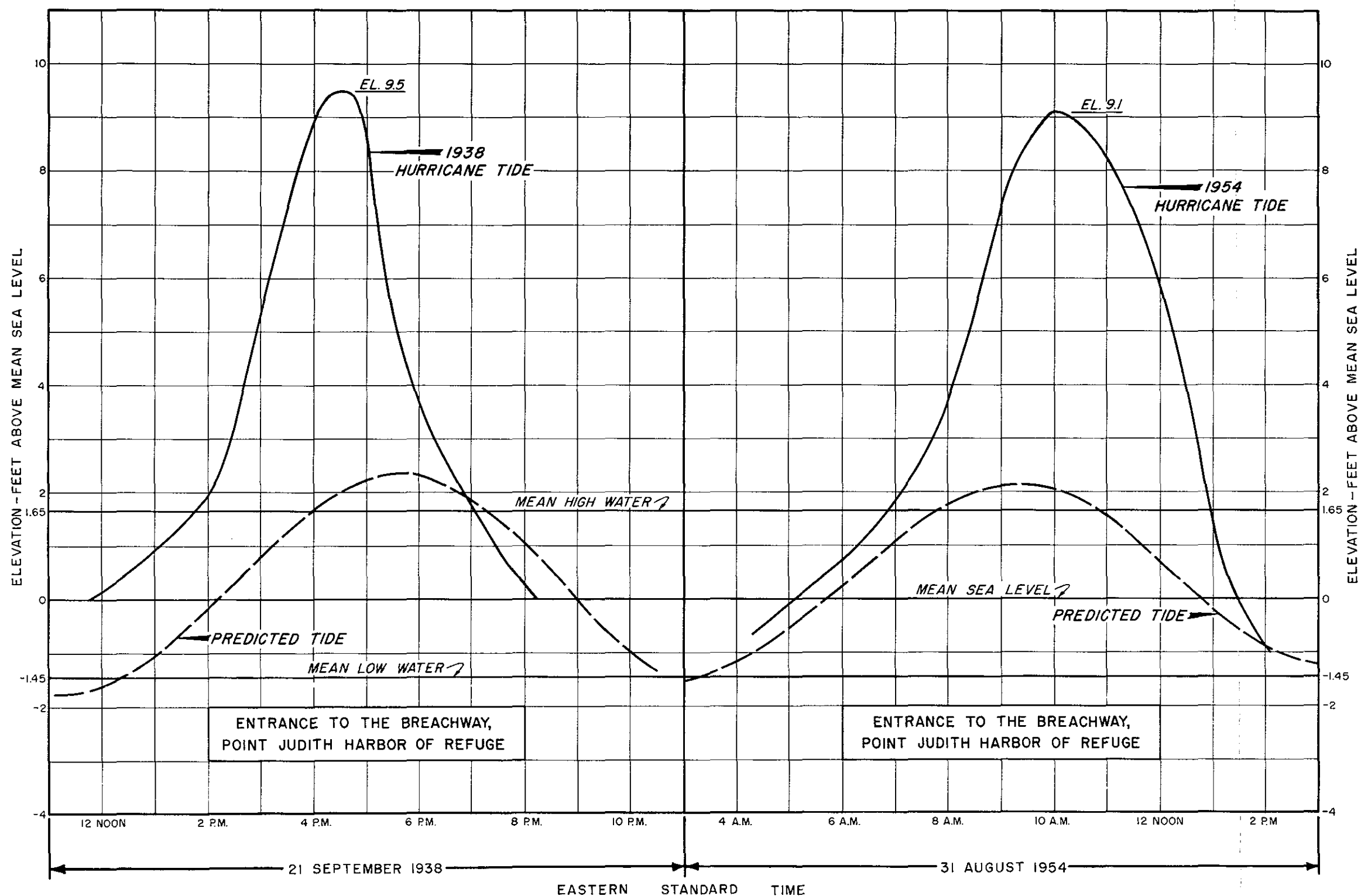
NOTE:

Hurricane of September 21, 1938, tide curve based on high water marks at Matunuck and hurricane tide at Newport, Rhode Island, stage related to Matunuck.

NOTE:

Hurricane Carol, August 31, 1954, tide curve based on high water marks at Matunuck and hurricane tide at Newport, Rhode Island, stage related to Matunuck.

WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
TIDE CURVES
HURRICANES OF 1938 & 1954
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 1961



NOTE:

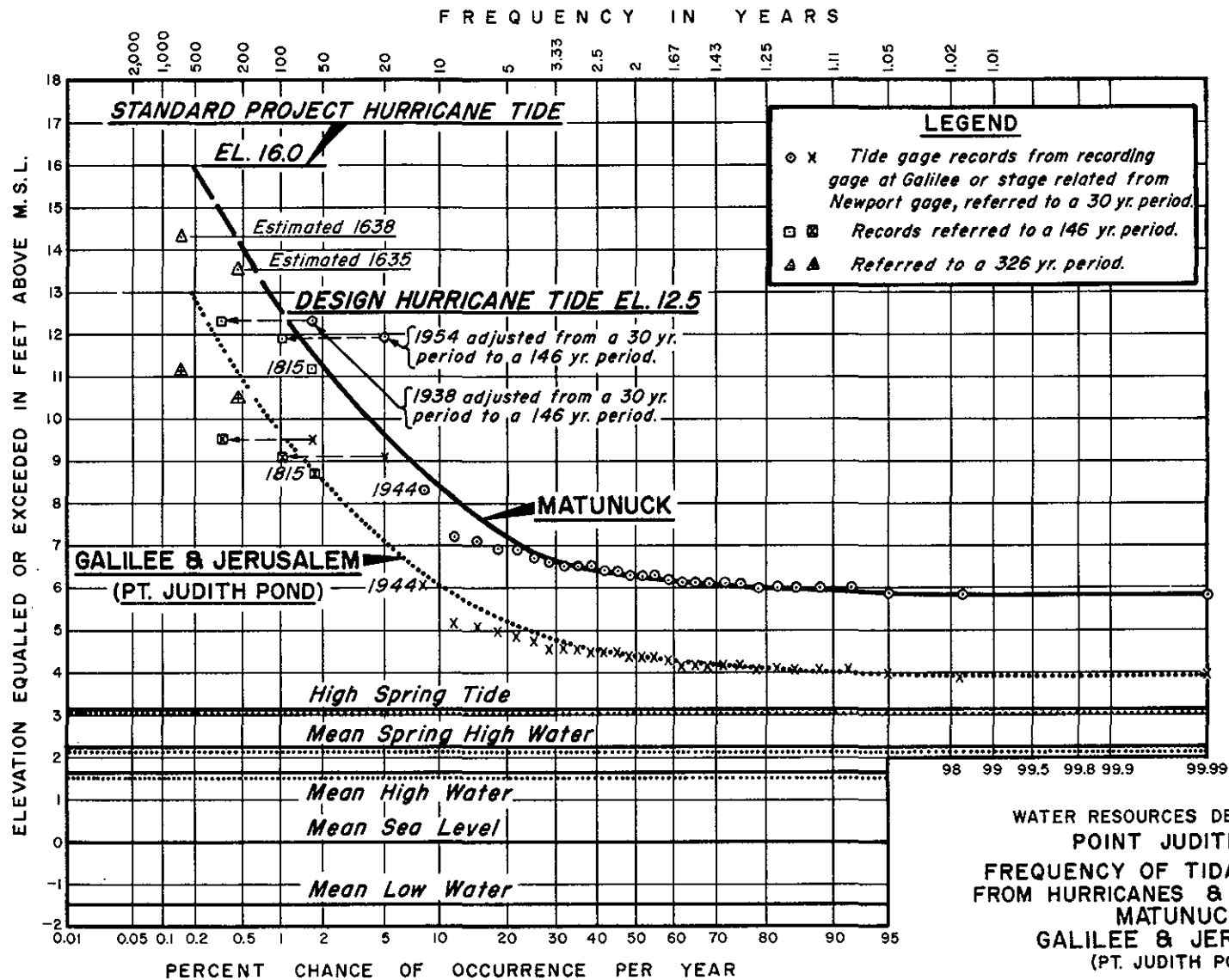
Hurricane of September 21, 1938 tide curve based on high water marks at Point Judith Harbor of Refuge area and hurricane tide at Newport, Rhode Island, stage related to entrance to The Breachway, Point Judith Harbor of Refuge.

NOTE:

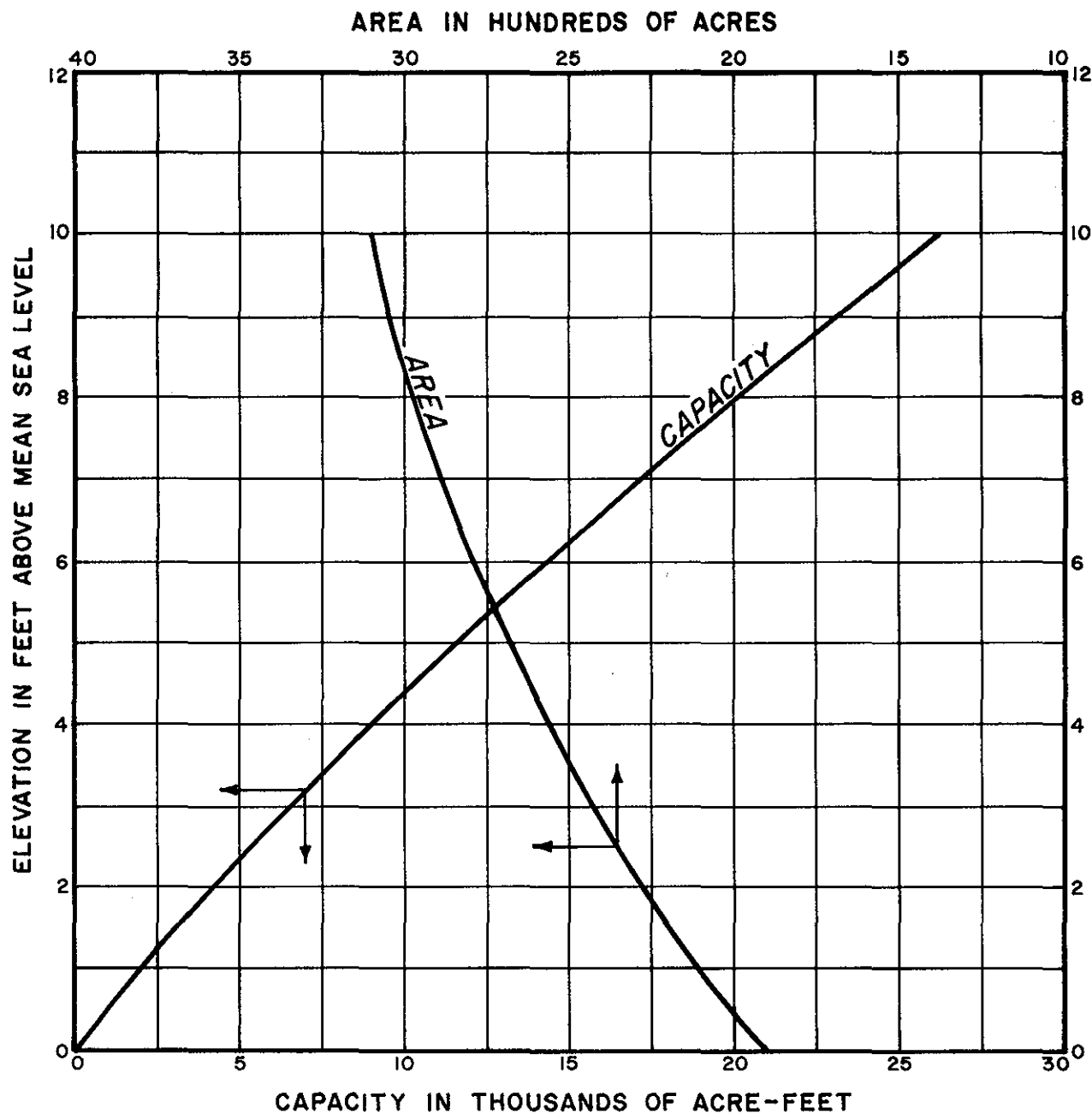
Hurricane Carol, August 31, 1954 tide curve based on high water marks at Point Judith Harbor of Refuge area and hurricane tide at Newport, Rhode Island, stage related to entrance to The Breachway, Point Judith Harbor of Refuge.

WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
TIDE CURVES
HURRICANES OF 1938 & 1954

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 56



WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
FREQUENCY OF TIDAL FLOODING
FROM HURRICANES & STORMS AT
MATUNUCK,
GALILEE & JERUSALEM
(PT. JUDITH POND)
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 1961



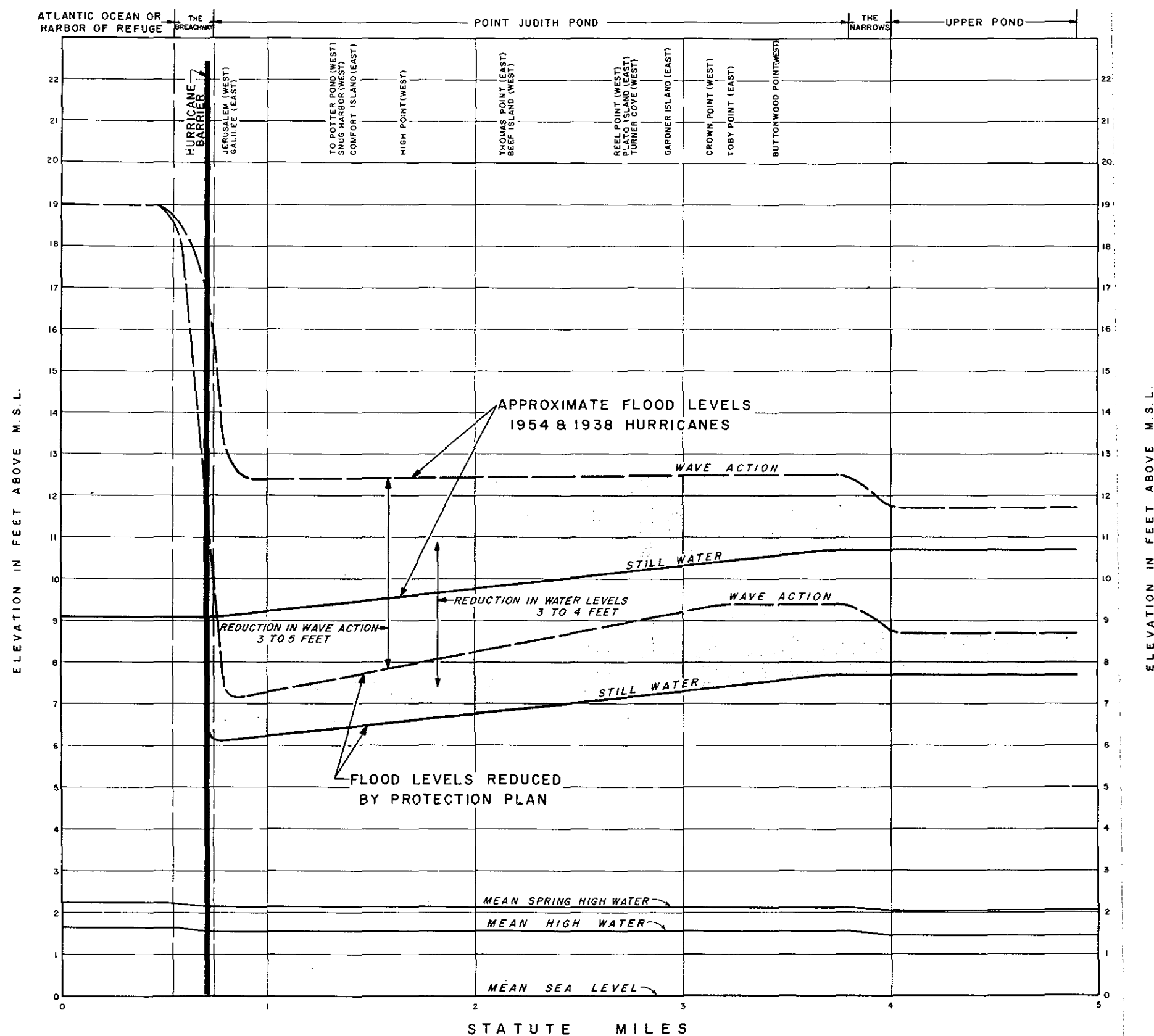
NOTE:

INCLUDES POINT JUDITH, POTTER AND UPPER PONDS

**WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
AREA AND CAPACITY CURVES**

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 1961
SCALE AS SHOWN

PLATE B-6



NOTE:
WATER LEVELS SHOWN ARE FOR THE 1954 HURRICANE TIDE (EL. 9.1) WHICH HAD A WIDER TIME BASE AND HENCE IS MORE CRITICAL THAN THE 1938 HURRICANE TIDE (EL. 9.5).

WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
EFFECT OF HURRICANE PROTECTION
PLAN IN REDUCING FLOOD LEVELS

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 1961
SCALE AS SHOWN

APPENDIX C

WATER RESOURCES DEVELOPMENT
DESIGN STUDIES AND COST ESTIMATES

APPENDIX C

APPENDIX C

WATER RESOURCES DEVELOPMENT DESIGN STUDIES AND COST ESTIMATES

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
C-1	INTRODUCTION	C-1
	GEOLOGY AND FOUNDATIONS	
C-2	Site Geology	C-1
C-3	Erosional History	C-2
C-4	Site investigation	C-3
C-5	Beach Composition	C-3
C-6	Foundation Conditions	C-4
C-7	Embankments	C-4
C-8	DESIGN CRITERIA	C-5
	SELECTED PLAN OF PROTECTION	
C-9	Description of Water Resources Development Plan	C-7
C-10	Modifications to Sewerage and Drainage Facilities	C-12
C-11	Lands and Damages	C-12
C-12	Relocations	C-13
C-13	Availability of Construction Material	C-13
C-14	Plan of Construction	C-13
C-15	Operation and Maintenance	C-14
	BASIS OF ESTIMATES OF FIRST COSTS AND ANNUAL COSTS	
C-16	Basis of Estimate	C-15
C-17	Unit Prices	C-15
C-18	Contingencies, Engineering and Overhead	C-15
	FIRST COSTS AND ANNUAL COSTS	
C-19	First Costs	C-15
C-20	Annual Costs	C-16
C-21	Cost Allocation and Apportionment	C-16

TABLES

<u>Number</u>		<u>Page</u>
C-1	Design Criteria	C-6
C-2	Summary of Pertinent Data	C-10
C-3	Estimated First Costs, Water Resources Development Plan	C-17
C-4	Estimated Annual Costs, Water Resources Development Plan	C-22
C-5	Estimated First Costs, Wakefield Channel and Anchorage	C-24
C-6	Estimated Annual Costs, Wakefield Channel and Anchorage	C-25
C-7	Estimated First Costs Summary, Water Resources Development Plan	C-26
C-8	Estimated Annual Costs Summary, Water Resources Development Plan	C-27

PLATES

C-1	General Plan
C-2	Plan and Cross Sections (West)
C-3	Plan and Cross Sections (East)
C-4	Breachway Control Structure
C-5	Plan of Borrow Explorations and Beach Profiles
C-6	Record of Borrow Explorations
C-7	Grain Size Characteristics, Beach and Borrow Materials

APPENDIX C

WATER RESOURCES DEVELOPMENT DESIGN STUDIES AND COST ESTIMATES

INTRODUCTION

C-1. The Water Resources Development plan for South Kingstown and Narragansett, Rhode Island, is a multiple-purpose plan combining hurricane protection, navigation and beach erosion control improvements. The studies leading to the selection of the plan show that: (1) a portion of the large quantity of sand fill material required for hurricane and beach protection can be obtained at substantial savings from the proposed navigational improvements; (2) navigational improvements can be enlarged at no increase in initial cost by using dredged material as fill, and (3) the beach erosion control improvements form an integral part of the hurricane protection and savings would be realized if the two were combined, for the reason that sand beaches diminish the height of attacking waves and permit a substantial reduction in the top elevation of protective structures. Certain of the proposed improvements are closely related and can be consolidated into a comprehensive plan. The savings in the cost of each purpose under the water resources development plan is particularly desirable for both Federal and non-Federal interests.

This appendix covers in detail the design features of the hurricane protection improvements and the cost estimates of the recommended Water Resources Development plan. Complete details and cost estimates for the navigation and beach erosion improvements as single purpose plans are given in Appendices D and E respectively.

The design studies and cost estimates are based on recent field surveys and subsurface investigations, U.S. Army Map Service Sheets 6666 I NE and 6766 IV NW, scale 1:25,000, U.S. Coast and Geodetic Survey Charts Nos. 268 and 1210, aerial photographs from the Department of Agriculture, and topographic and hydrographic surveys completed in 1959 by the U.S. Army, Corps of Engineers.

GEOLOGY AND FOUNDATIONS

C-2. SITE GEOLOGY

The southern shore of Rhode Island from Watch Hill near the Connecticut State line eastward to Point Judith at the entrance to Narragansett Bay, a distance of about 20 miles, constitutes one of the most extensive coastal sand deposits in New England.

What was once a large sand plain in this area became submerged, and over a period of time marine forces eroded indentations and lagoons between the more resistant headlands of terminal moraine. Sand beaches and dunes occur between the headlands where glacial sands have been retained. Behind the beaches and lagoons is the more resistant deposit of boulders and till known as the Harbor Hill moraine. Watch Hill forms the westernmost headland of the exposed string of beaches and the Point Judith headland is the eastern promontory. Between these two prongs the sand stretches and is held seaward by the lesser headlands of Weekapaug, Quonochontaug, Green Hill and Matunuck Point.

The headlands and beaches are eroding rapidly from loss of sand by wind and waves, and flanking by storms. The inward arching of the beaches leaves offshore patches of coarse debris at the base of the receding headlands. The lesser headlands offer some protection to the beaches from along shore currents but offer very little protection from direct wave attack from the south. The beaches are overtopped and breached and dunes are destroyed during hurricanes and severe winter storms.

C-3. EROSIONAL HISTORY

Prior to 1839 the inlet to Point Judith Pond lay 2,700 feet to the west of the existing opening. A smaller inlet also existed at that time leading into Potter Pond, just west of Matunuck Point. By 1869-1875 the Point Judith Pond inlet widened and migrated eastward more than 500 feet. Around 1909 the State of Rhode Island in cooperation with local interests opened a new inlet (The Breachway) at the present location. The former inlets were closed partly by filling and partly by natural processes.

During the period 1891 to 1914 rock breakwaters were constructed by the Federal government to form the Point Judith Harbor of Refuge. Prior accretion of about 800 feet of the high water shoreline at Galilee was followed thereafter by severe erosion, causing the shoreline in 1946 to resemble that of 1839. Practically no change occurred to the shoreline east of Sand Hill Cove State beach during the period. Accretion occurred west of the west shore arm breakwater at Jerusalem and appreciable amounts of sand passed through the structure into the Harbor of Refuge. The breakwater arm was made sand tight in 1950.

The counter-clockwise littoral drift within the Harbor of Refuge is indicated by the existence of a submarine bar nearly one-half mile long extending southward from the east jetty at the Breachway. Flood tide currents through the Breachway carry the littoral materials into Point Judith Pond. The bar has restricted navigation for deeper draft vessels to a channel about 250 feet wide close to the west breakwater.

Hydrographic profiles taken in 1946 and 1959 within the Harbor of Refuge indicate average beach slopes between +2 feet and -20 feet, mean sea level, of 1:65 and 1:70 at Galilee. The comparable slopes at Sand Hill Cove State Beach averaged 1:69 in 1946, and 1:65 in 1959. The foreshore slope where beach protective measures are planned is about 1:20.

During the period 1946 to 1959, a deepening occurred southeast of the east jetty of the Breachway and an increase in shoaling extended the submarine bar almost to the west entrance of the Harbor of Refuge. Maintenance dredging would be required to maintain a channel through the bar and it may prove desirable to extend the jetty southward from the east side of the Breachway to reduce shoaling. Overdredging in this area for borrow material for hurricane and beach protection would be advance channel maintenance.

Recession of about 700 feet of the high water shoreline along what is now East Matunuck State Beach occurred from 1839 to 1946. Indications are that the recession is continuing at an average rate of about 2.5 feet per year. Except for the filling-in of the small inlet (from the ocean) to Potter Pond, there has been very little shoreline change to the westward of Matunuck Point from 1839 to the last survey in 1946. The foreshore slopes at East Matunuck average 1:20; Matunuck Beach, 1:10.

C-4. SITE INVESTIGATIONS

Site investigations consisted of geologic reconnaissance and 16 drive-sample borings to determine the suitability of dredged material from requested navigation improvements for hurricane and beach protection improvements. Two borings were made in Point Judith Pond: one in the large bar in the Harbor of Refuge; nine in the marshes behind Jerusalem; one in Potter Pond behind East Matunuck State Beach; and three in the outwash terrace northwest of the study area. In addition, surface samples were obtained from beach profiles to establish the character of beach materials and to indicate recent changes in beach composition. The results of the borings are shown on Plate C-6.

C-5. BEACH COMPOSITION

In 1959 surface beach samples were obtained along 23 profiles at East Matunuck State Beach. The samples were taken at the berm, between the berm and high water, mid-tide, low water, and at 6-foot depth intervals out to the 30-foot depth. Comparison of grain sizes at corresponding stations for 1946, 1957 and 1959 are shown on Plate C-7. Materials seaward of the 6-foot depth have decreased in size and contours from the profile soundings indicate erosional inroads toward the ends of the beach, particularly east of Matunuck Point where broad shallow gullying has begun in the 15-foot depth range.

A scatter diagram of the median diameters of all profile samples tested yields a concentric pattern and considerable concentration at 0.8 mm. size for all submerged portions of the beach. This might be taken as a desirable grain size for materials placed on the beach, particularly since beach slope appears to be a much less critical function of grain size above that size. Barring a radical steepening of the beach, however, it appears possible that the materials in the range of 0.2 to 0.4 mm. may be satisfactory and most of the fill obtainable from requested navigation improvements falls marginally near the lower end of the range. The average slopes for East Matunuck State Beach in 1959 were approximately as follows:

Elevation	+4 ft.	to -5 ft.	1:20
"	-5	to -10	1:40
"	+4	to -15	1:45
"	+4	to -30	1:100

Convincing evidence of the importance of wind transportation of sands into the lagoons is seen in winter, when sand covers the ice along the southern margins of the ponds. Surficial bottom sampling has indicated that the southern parts of the ponds are beach sand while the northern and central parts are organic silts and till or outwash sands and gravels.

The sand particle settling diameter with respect to an upward air current corresponding to the average wind velocity from the direction of maximum duration is 0.3 mm, while much finer sizes occur immediately seaward where wetting can increase cohesion and thereby prevent movement by onshore winds.

C-6. FOUNDATION CONDITIONS

The structures being considered for hurricane and beach protection do not create any special foundation requirements. The existing beaches will adequately support the proposed works except at a minor marsh crossing at Sand Hill Cove and at the relocation of Succotash Road where unsatisfactory material will be replaced. The sand extends to at least one or two feet below mean sea level under the entire bar crest. A thin stratum of silt occurs between elevation -25.0 and elevation -40.0 feet, mean sea level, at the Breachway where the foundation materials are largely loose to moderately compact fine sands.

C-7. EMBANKMENTS

The proposed embankments will not exceed about 10 feet in height and no foundation problems are anticipated which require special consideration in the embankment design. While a nominal amount of stripping will be required, particularly in the marsh

areas, the foundation materials consist mainly of strong and incompressible sand.

Embankments constructed of earth or sand will have inner slopes protected from erosion by wind and rain by beach grass plantings or seeded top soil. Seaward slopes would be protected against large storm waves by rock slopes or rock revetments.

DESIGN CRITERIA

C-8. The Standard Project Flood for the Point Judith area would cause still water flood levels to reach elevations of 16.0 feet above mean sea level along the exposed coast, and 13.6 feet above mean sea level within the Harbor of Refuge. Preliminary plans of a number of alignments and cross-sections to provide complete protection were not acceptable for the following reasons: (1) construction costs exceeded the recurring damages in some areas; (2) the barrier restricted access to the beaches and obstructed the view of the water, and (3) the base width of the higher structures required much more land condemnation.

The flood of record was selected as the basis of design of the protective barriers, 12.5 feet above mean sea level for Matunuck-Jerusalem, and 10.5 feet above mean sea level for the Galilee-Sand Hill Cove area. Other pertinent design criteria for hurricane protection is tabulated in Table C-1.

The rock breakwaters enclosing the Harbor of Refuge reduce the wave set-up that occurs on the ocean beaches and lowers hurricane tidal flood levels by about 2 feet, thus allowing lower protective structures.

Several alignments and cross-sections were investigated for economical structures that would provide protection against the greatest storm experienced in over 326 years. The flood level used as the basis of design occurred during the hurricane of 21 September 1938 which produced levels of 12.3 and 10.5 feet above mean sea level, outside and inside the Harbor of Refuge, respectively. It was found that economical structures that would overcome local objections could be constructed to prevent about 90 percent of the estimated recurring damages.

The design criteria for the navigation improvements is contained in Appendix D, and that for beach erosion improvements in Appendix E.

TABLE C-1

DESIGN CRITERIA
POINT JUDITH AREA

Wind Direction and Velocity, m.p.h.	SE-84
Wave Period, seconds	13.5
Maximum Wave Height 1/2 mile off-shore	33.0
Wave Length, feet	933
Design Still water Elevations	
Outside Harbor of Refuge, feet, m.s.l.	12.5
Inside " " " " "	10.5
Maximum Wave Height, Toe of Slope	
Outside Harbor of Refuge, feet	10.0
Inside " " " " "	8.0

The design of structures has followed published standards of the Office of the Chief of Engineers and the Beach Erosion Board. Wave run-up was computed for a large number of different combinations of composite and simple slopes and berm widths by the method outlined in "Wave Run-up on Composite Slopes" (1) and a design selected to prevent overtopping of the protective structures. The assumption was made that the run-up on rock slopes would be reduced 50 percent because of the roughness factor.

Sand sections were selected where the required distance from the water to prevent overtopping could be obtained with minimum displacements to existing property; in other locations closer to the water it was necessary to use rock dikes and revetments. Rock revetment was used to protect and stabilize the vulnerable headlands. Rock sizes and the thicknesses required for the cover, bedding and filter layers were based on the technical paper "Laboratory Investigations of Rubble-Mound Breakwaters" (2) dated June 1957, using a K_d displacement factor of 3.2. A minimum rock size of 1,000 pounds was selected for seaward slopes to provide for minimum maintenance. Earth dikes were selected further inland where wave action would be diminished.

- (1) By Thorndike Saville, Jr., Beach Erosion Board, Washington, D.C.
- (2) By Robert Y. Hudson, Waterways Experiment Station, Vicksburg, Mississippi

The breachway control structure was designed as a gravity monolith with heavy rock approaches. The concrete abutment foundation pressures do not exceed the maximum allowable of 6,000#/ft.²; no bearing piles are required.

The selected width of the ungated opening in the Breachway is 150 feet. It coincides with the existing authorized channel and is the largest ungated opening that will give the needed tidal-flood reduction in the ponds. See Appendix B for complete details on tidal-flood routings.

Preliminary designs and estimates were made for partial gating of the Breachway to effect a larger reduction in flood levels. Growth of population and future development may warrant partial gates at the time of final design. Therefore, the cost of fabrication of gates and abutment changes, estimated at \$100,000, are included in the overall estimate.

SELECTED PLAN OF PROTECTION

C-9. DESCRIPTION OF WATER RESOURCES DEVELOPMENT PLAN

The plan of improvements is shown on Plates C-2 and C-3 and is described as follows:

a. Matunuck Beach.

(1) Earth dike. An earth-filled dike, covered with seeded topsoil, would be provided from Station 0+00 to 3+25. The top width would be 10 feet with a variable elevation from 16.0 to 20.0 feet above mean sea level, and side slopes of 1 on 3 on the ocean side and 1 on 2 on the land side. The dirt access road to the beach house would be blocked-off and the existing paved road to the west would be used as the entrance.

(2) Rock dike. A rock dike would be constructed on the dune ridge from Station 3+25 to 31+00. The top would be at elevation 20.0 feet above mean sea level. Low areas behind the dike would be filled with sand to blend in with the existing grade. The beach area in front of the dike would be reshaped to match the existing slope of about 1 on 10. The rock dike is low enough to afford easy access to the beach. Details of rock sizes, slopes and elevations are shown in Section A-A on Plate C-2. New road construction would be accomplished on top of the dike, near Ocean Avenue, to reduce the amount of land condemnation.

b. Matunuck Point.

(1) Rock revetment. In order to stabilize the vulnerable headland at Matunuck Point and prevent subsequent erosion, a rock revetment would be provided on the face of a sand dike, from Station 31+00 to 43+00. The top width would be 20 feet with a top elevation of 20.0 feet above mean sea level. See Section B-B on Plate C-2. Utilizing the dune ridge reduces the quantity of material required and minimizes condemnation.

The badly eroded shore from Station 43+00 to 50+00 would be graded and shaped for the continuation of the rock revetment around the headland and under the beach raising and widening section. Details are shown in Section C-C on Plate C-2.

c. East Matunuck State Beach.

(1) Beach raising and widening. The foreshore between Station 50+00 and 100+00 would be improved as authorized in the beach erosion project (see Appendix E.) Briefly, the plan is to widen approximately 3,830 feet of beach to a 150-foot width by direct placement of suitable sandfill, construction of 8 groins each about 260 feet long, and installation of sand fences, the construction of groins to be deferred pending demonstration of need except for the most easterly groin and that near the middle of the shore frontage. For hurricane protection on the backshore a 100-foot wide level sand berm at elevation 12.5 feet, and a backup sand dune at elevation 17.5 feet above mean sea level, would be provided. The groins of the authorized beach erosion project would be extended under the sand berm to beyond the toe of the sand dike. Succotash Road would be relocated and benched into the rear slope of the sand dike. Details are as shown in Section D-D on Plate C-2.

d. Jerusalem-Galilee Breachway.

(1) Breachway control structure. An ungated concrete and rock control structure would be constructed in the center of the breachway opening. The effective width would be 150 feet and the sill depth would be 22.0 feet below mean low water. The top of the abutments adjacent to the channel would be at elevation 12.0 feet above mean sea level, and the rock approaches would be at elevation 16.0 feet above mean sea level. Details, alignment and sections of the structure are shown on Plate C-4.

e. Galilee.

(1) Concrete-pile wall. A pre-cast concrete pile wall would be driven at the Galilee Beach Club, between Station 114+20 and 115+50. The top would be at elevation 17.0 feet above mean sea level. A swing-type bulkhead door would be provided through the wall to allow normal access to the beach at basement level.

A wall would be constructed also from Station 124+00 to 139+00. This wall would act as a backstop for run-up and prevent overtopping of the dunes. Steps would be provided over the wall to facilitate access to the beach. A five foot berm, at grade level, and sand fill would be placed in front of the wall to strengthen the existing dunes. The top of the wall varies from 20.0 to 22.0 feet above mean sea level, depending on the distance from the shoreline. See Section E-E on Plate C-3.

f. Sand Hill Cove State Beach and Sand Hill Cove.

(1) Beach raising and widening. The shore between Station 139+00 and 172+00 includes the Sand Hill Cove State Beach. In 1955 a beach erosion project constructed by the State in cooperation with the Federal government was completed along the State-owned property. It consisted of widening the foreshore an average of 65 feet by direct placement of sand fill over a length of one-half mile and the construction of 5 impermeable rock groins. Under the Water Resources Development plan additional sand fill would be provided to further widen and raise the beach between the existing groins. A 50-foot wide level berm at elevation 10.5 feet above mean sea level, and a sand backup dike to elevation 17.0 feet above mean sea level would also be provided. Pre-cast concrete piles would be driven around the beach house as shown in Section F-F on Plate C-3.

For the area seaward of Stanton Avenue in Sand Hill Cove, the plan provides for beach raising and widening with a 50-foot level berm at elevation 10.5 feet above mean sea level and a rock backup dike to elevation 14.0 feet above mean sea level. The rock dike is more effective in reducing the run-up and was used at this location to minimize problems of beach access and the loss of ocean view to the rear cottages. See Section G-G on Plate C-3.

(2) Earth dike. An earth filled dike with 1 on 3 side slopes would be constructed from Station 172+00 to 178+25 to complete the closure to high ground on the east. The top width would be 10 feet with a variable height from 14.0 feet to 13.0 feet above mean sea level. The seaward slope would be faced with rock spalls and the remainder would be seeded top soil.

g. Navigation Improvements. Navigation improvements for the area, as described in Appendix D, would be included and undertaken concurrently with the construction of the hurricane and beach erosion control improvements, using the dredged sand for fill and effecting savings for each purpose. Since additional sand fill beyond that obtainable from justified navigation improvements is required, larger and deeper channels and anchorages can be obtained at no increase in initial cost. The enlarged improvements would include (1) dredging

a new entrance channel from the west entrance of the Harbor of Refuge to Point Judith Pond, (2) dredging an additional 5 acres of anchorage within the pond at Galilee, and (3) dredging a 2-foot deeper channel and anchorage at Snug Harbor.

TABLE C-2

SUMMARY OF PERTINENT DATA
POINT JUDITH AREA

MATUNUCK

EARTH DIKE - Station 0+00 to 3.25		
Length, overall, feet		325
Top elevation, feet, m.s.l.	16.0 to	20.0
Top width, feet, seeded topsoil		15
Slope, outer, seeded topsoil		1:3
Slope, inner, seeded topsoil		1:3
ROCK DIKE - Station 3+25 to 31+00		
Length, overall, feet		2,775
Top elevation, feet, m.s.l.		20.0
Top width, feet		10
Slope, outer		1:3
Slope, inner		1:2
Rock size, tons (ocean side)		0.5

MATUNUCK POINT

ROCK-FACED SAND DIKE - Station 31+00 to 43+00		
Length, overall, feet		1,200
Top elevation, feet, m.s.l.		20.0
Top width, feet		20
Slope, outer		1:3
Slope, inner		1:3
Rock size, tons		1.2
ROCK REVETMENT - Station 43+00 to 50+00		
Length, feet		700
Top elevation, feet, m.s.l.		20.0
Top width, feet		10
Slope, outer		1:5
Slope, inner		1:3
Rock size, tons		2

TABLE C-2 (continued)

EAST MATUNUCK

PROTECTIVE BEACH - Station 50+00 to 100+00	
Length, feet	5,000
Berm elevation, feet, m.s.l.	12.5
Berm width, feet	100
Backup dike elevation, feet, m.s.l.	17.5
Top width, feet	25
Slope, outer	1:5
Slope, inner	1:5
Beach slope	1:20

JERUSALEM - GALILEE

BREACHWAY - Station 102+70 to 112+00	
Effective opening, feet	150
Rock dike elevation, feet, m.s.l.	16.0
Top width, feet	15
Slopes	1:2
Rock sizes, tons	5.7
Concrete abutments, lower elevation	12.0
Concrete abutments, upper elevation	16.0
Rock sill, elevation, feet, m.s.l.	-23.5
Slopes	1:4
Sill width, feet	20
Walkway on fender piles, elevation, feet, m.s.l.	6.0

GALILEE

WALLS - Station 114+20 to 115+50, and 124+00 to 139+00	
Type: Pre-cast concrete	
Length, overall, feet	1,630
Top elevation, station 114+20 to 115+50 ft., m.s.l.	17.0
Top elevation, station 124+00 to 139+00 ft., msl	20.0-22.0
Pile length, feet	20-22
Berm width, feet	5
Berm elevation, feet, m.s.l.	16.5-18.5

SAND HILL COVE STATE BEACH AND SAND HILL COVE

PROTECTIVE BEACH - Station 139+00 to 157+00	
Sand beach and backup dike, top elevation, m.s.l.	17.0
Top width, feet	15
Outer slope	1:5
Inner slope	1:5
Berm elevation, feet, m.s.l.	10.5
Berm width, feet	50
Beach slope	1:15

TABLE C-2 (continued)

SAND HILL COVE STATE BEACH AND SAND HILL COVE (continued)

PROTECTIVE BEACH - Station 157+00 to 172+50	
Sand beach and rock backup dike, top elev., m.s.l.	14.0
Top width, feet	10.0
Outer slope	1:3
Inner slope	1:2
Rock size, tons	0.5
Berm elevation, feet, m.s.l.	10.5
Berm width, feet	50
Beach slope	1:15
EARTH DIKE - Station 172+50 to 178+25	
Length, feet	575
Top elevation, feet, m.s.l.	14.0-13.0
Top width, feet	10
Slope, outer rock-faced	1:3
Slope, inner seeded loam	1:3

C-10. MODIFICATION TO SEWERAGE AND DRAINAGE FACILITIES

a. Modification to sewer lines. No existing sewer lines cross the beach along the alignment of the proposed protective barrier. No interference is anticipated in future sewer works during the life of the project.

b. Modification to drainage facilities. The only drainage line crossing the barrier alignment is at about Station 165+50, which drains surface run-off from the cottage area in Sand Hill Cove. This 12-inch pipe would be extended and hidden from view under the water; a check-valve would be installed to prevent back flooding during hurricanes.

C-11. LANDS AND DAMAGES

Furnishing necessary lands and rights-of-way for the construction of the multiple-purpose plan is one requirement of local cooperation. About 30 percent of the land required is already owned by the State of Rhode Island, the remainder is owned by private and commercial interests. Approximately 156 individual property owners are involved.

Private homes could be raised or relocated wherever possible. Temporary and permanent easements would be secured so that removal or acquisition of improvements would be a minimum.

The estimated costs would be \$450,000, including \$4,000 for temporary easement rights.

C-12. **RELOCATIONS**

The alignment is along the dune ridge and relocation of water lines or gas lines will not be required. Telephone and electric lines would be moved where roads are relocated.

Matunuck Beach Road would be reconstructed and raised on the rock dike from Station 26+50 to 31+00. Access ramps would be provided to adjacent cottages.

Succotash Road would be relocated and benched into the rear slope of the sand dike at elevation 8.5 feet above mean sea level between Station 70+00 and 92+00. Any added cost of an alternate road alignment would be borne by local interests.

The purchase or relocation of buildings would be required at Matunuck Point, Jerusalem and the Sand Hill Cove area, as described in paragraph C-11.

C-13. **AVAILABILITY OF CONSTRUCTION MATERIALS**

a. Stone. High grade granite suitable for coastal protection works is available at commercial quarries about 20 miles truck haul distance from the site. Any size stone up to about 20 tons can be produced from these quarries and considerable suitable material can be sorted from existing waste piles.

b. Gravel. Bank run gravels can be obtained from morainic materials and parts of the glacial outwash within 5 miles haul distance from the site. Most of the materials are sandy, cobbly gravels with occasional concentrations of intermediate sizes.

c. Sand. Fine to very fine sands can be obtained by improvement and maintenance dredging in the Harbor of Refuge and Point Judith Pond. Additional fine sands can be dredged from Potter Pond, near the beach. Somewhat coarser sands can be obtained in sufficient quantity for the entire construction from a land source within 7 miles truck haul distance from the site.

d. Concrete aggregates. Two transit-mix plants are located within a 20 mile radius of the site. The nearest, in Wakefield, is about 10 miles truck haul distance from the site.

C-14. **PLAN OF CONSTRUCTION**

The barrier alignment is approximately three miles long and the existing topography lends itself to simultaneous construction of all phases of the project. Actual construction would probably begin in the fall and would require about 21 months to complete. The

construction schedule would be arranged to cause the least possible interference of the recreational use of the area and would generally be as follows:

a. Fall and early winter. Hydraulic dredging of sand fill for beach raising and widening would be coordinated with navigational dredging and would be started immediately. Access roads, relocation of buildings and drainage modifications would also be accomplished during this period.

Breachway modifications would be undertaken concurrently with barrier construction and every effort would be made to minimize interference with commercial and recreational navigation.

b. Late winter and spring. Hydraulic dredging and fill operations would continue along the entire project. Stock piling of materials would be carried on and the initial construction of rock dikes and revetments would commence with the break of winter weather.

c. Summer. All hydraulic sand fill operations for beach raising and widening at East Matunuck and Sand Hill Cove State Beaches would be suspended during the summer season. Only construction of rock dikes, revetments and other land structures would be carried on during this period.

d. Fall and winter. Hydraulic dredging and fill operations would be resumed at incompleated areas. Rock dikes and revetments would be brought up to final grades and the rock groins constructed for the beach erosion portion of the project.

e. Late winter and spring. All pre-cast concrete pile walls would be completed during this period and final trim of beach slopes accomplished. Fender piles and other appurtenances would be completed at the Breachway Control Structure. Final grading and seeding of loamed slopes and planting of beach grass would complete the construction of the project.

C-15. OPERATION AND MAINTENANCE

Upon completion of the Water Resources Development project, local interests would be responsible for the operation and maintenance of the hurricane and beach erosion features. The principal operation feature is the closing of the check-valve at Sand Hill Cove and the bulkhead door at the Galilee Beach Club. The maintenance items consist of beach nourishment (sand fill replacement) and repair of the rock dikes, rock revetments and groins. See Table C-8 for the breakdown and costs of non-Federal and Federal maintenance items.

BASIS OF ESTIMATES OF FIRST COSTS AND ANNUAL COSTS

C-16. BASIS OF ESTIMATE

The cost of the Water Resources Development plan has been estimated on the basis of standard construction methods. Estimates of quantities have been made from the general plans, typical cross sections and details and were based on the computed in-place volume of the earth and rock fill structures. A 33 percent overall allowance was made for loss of fines and other losses of the beach fill obtained from hydraulic dredging of navigational areas. Rock allowances were also made for settlement of rock structures.

The estimate also provides for grading and grassing of earth dikes to blend in with the existing terrain, and planting of beach grass on the sand barriers to retard wind erosion.

C-17. UNIT PRICES

Unit prices are based on averages for similar types of projects, either constructed, under construction, or under contract in New England and, where applicable, recent and similar construction within the State. Adopted unit prices are based on a 1961 price level and adjustments made for the availability and location of the material required.

C-18. CONTINGENCIES, ENGINEERING AND OVERHEAD

The estimate includes an allowance of about 20 percent for contingencies. The cost of engineering, design, supervision, and administration are estimated lump sums based on knowledge of the site and recent experience for this type of work. The cost of items for various sections of the plan are shown on subsequent pages.

FIRST COSTS AND ANNUAL COSTS

C-19. FIRST COSTS

The first cost of the recommended Water Resources Development Project is estimated at \$3,565,000 (see Table C-3), of which \$2,413,600 would be borne by the United States. Local interests would be required to contribute about 32 percent of the first cost of the project, comprised of (1) a cash contribution to the United States, presently estimated at \$701,400; and (2) lands, easements, rights-of-way and relocations necessary for construction of the project, presently estimated at \$450,000. See Appendix F for Cost Allocation.

C-20. ANNUAL COSTS

The total annual costs for the Water Resources Development Project amount to an estimated \$219,400. (See Table C-4). Of this amount, \$103,900, including \$600.00 annual cost to the U.S. Coast Guard, represents Federal annual costs, and \$115,500 non-Federal. Annual costs are based on 2-5/8 percent interest on the Federal investment, 3.5 percent interest on the non-Federal investment, amortization over a period of 50 years and operation and maintenance. Since the construction period is less than two years and much of the project would be immediately useful, interest during construction has not been charged against the project.

C-21. COST ALLOCATION AND APPORTIONMENT

The Water Resources Development Project consists of two elements: (1) Wakefield Channel and Anchorage, and (2) the entire remainder of the project. Due to the distance of the Wakefield Channel and Anchorage from the proposed hurricane and beach protection, it would not be economical to transport dredged material to the barrier beaches. First costs and annual costs for the Wakefield Channel and Anchorage are given in Tables C-5 and C-6. For the remainder of the project, an allocation of costs between purposes and an apportionment of costs between Federal and non-Federal interests was necessary. This allocation and apportionment are described in Appendix F. A summary of first costs and annual costs for the two elements and the total project are given in Tables C-7 and C-8.

TABLE C-3

ESTIMATED FIRST COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>SITE PREPARATION</u>	1	job	L.S.	\$ 5,000
<u>MATUNUCK BEACH</u>				
<u>EARTH DIKE</u>				
Sand Fill	6,000	c.y.	1.09	6,000
Loam	600	c.y.	3.50	2,000
				8,000
Contingencies				2,000
TOTAL COST - EARTH DIKE				\$ 10,000
<u>ROCK DIKE</u>				
Excavation	22,000	c.y.	0.50	11,000
Back Fill	23,200	c.y.	0.50	11,000
Sand Fill	3,000	c.y.	1.09	3,000
Gravel	24,000	c.y.	1.50	36,000
Rock Fill, Armor Stone	10,300	c.y.	6.00	62,000
Rock Bedding, Quarry Run	5,200	c.y.	4.00	21,000
Crushed Stone, Filter	1,500	c.y.	2.00	3,000
				147,000
Contingencies				30,000
TOTAL COST - ROCK DIKE				\$ 177,000
<u>ROAD RELOCATION</u>				
Gravel	3,300	c.y.	1.50	5,000
Loam	300	c.y.	3.50	1,000
Paving	1,500	s.y.	2.00	3,000
Drainage	1	job	L.S.	5,000
				14,000
Contingencies				3,000
TOTAL COST - ROAD RELOCATION				\$ 17,000
TOTAL COST - MATUNUCK BEACH				\$ 204,000

TABLE C-3 (continued)

ESTIMATED FIRST COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>MATUNUCK POINT</u>				
<u>ROCK FACED SAND DIKE</u>				
Sand Fill	22,000	c.y.	1.09	\$ 24,000
Rock Fill, Armor Stone	15,000	c.y.	6.00	90,000
Rock Bedding, Quarry Run	4,800	c.y.	4.00	19,000
Crushed Stone, Filter	1,500	c.y.	2.00	3,000
				<u>136,000</u>
Contingencies				28,000
TOTAL COST - ROCK FACED SAND DIKE				\$ <u>164,000</u>
<u>ROCK REVETMENT</u>				
Gravel	2,700	c.y.	1.50	4,000
Rock Fill, Armor Stone	17,000	c.y.	6.00	102,000
Rock Bedding, Quarry Run	4,800	c.y.	4.00	19,000
Crushed Stone, Filter	2,000	c.y.	2.00	4,000
				<u>129,000</u>
Contingencies				26,000
TOTAL COST - ROCK REVETMENT				\$ <u>155,000</u>
TOTAL COST - MATUNUCK POINT				\$ 319,000
<u>EAST MATUNUCK BEACH</u>				
<u>SAND DIKE</u>				
Sand fill	448,000	c.y.	1.09	489,000
Contingencies				98,000
TOTAL COST - SAND DIKE				\$ <u>587,000</u>
<u>BEACH</u>				
Sand Fill	90,000	c.y.	1.09	98,000
Rock Fill, Groins	8,930	c.y.	10.70	96,000
Sand Fence	7,700	l.f.	0.93	7,000
				<u>201,000</u>
Contingencies				30,000
TOTAL COST - BEACH				\$ <u>231,000</u>

TABLE C-3 (continued)

ESTIMATED FIRST COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>EAST MATUNUCK BEACH (continued)</u>				
<u>ROAD RELOCATION</u>				
Sand Fill	13,000	c.y.	1.09	\$ 14,000
Gravel	2,000	c.y.	1.50	3,000
Loam	1,200	c.y.	3.50	4,000
Paving	7,500	s.y.	2.00	15,000
Drainage Modification	1	job	L.S.	4,000
				<u>40,000</u>
Contingencies				9,000
TOTAL COST - ROAD RELOCATION				\$ <u>49,000</u>
TOTAL COST - EAST MATUNUCK BEACH				\$ 867,000
<u>BREACHWAY</u>				
Excavation, Cofferdam and Channel	4,000	c.y.	5.00	20,000
Excavation, General	2,500	c.y.	2.00	5,000
Gravel	700	c.y.	3.00	2,000
Concrete, Tremie	2,400	c.y.	25.00	60,000
Concrete, Mass	2,100	c.y.	40.00	84,000
Steel Sheet Piling	17,000	s.f.	4.00	68,000
Rock Fill, Armor Stone in Water	4,000	c.y.	10.00	40,000
Rock Fill, Armor stone	8,000	c.y.	8.00	64,000
Rock Bedding, Quarry Run	3,300	c.y.	6.00	20,000
Crushed Stone, Filter	500	c.y.	4.00	2,000
Fender Guide System	1	job	L.S.	30,000
Partial Gating	1	job	L.S.	100,000
				<u>495,000</u>
Contingencies				99,000
TOTAL COST - BREACHWAY				\$ <u>594,000</u>
<u>GALILEE</u>				
Precast Concrete Sheet Pile	1,750	l.f.	75.00	131,000
Sand Fill	3,000	c.y.	1.09	3,000
				<u>134,000</u>
Contingencies				27,000
TOTAL COST - GALILEE				\$ <u>161,000</u>

TABLE C-3 (continued)

ESTIMATED FIRST COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>SAND HILL COVE STATE BEACH AND SAND HILL COVE</u>				
Sand Fill	94,000	c.y.	1.09	\$ 103,000
Loam	600	c.y.	3.50	2,000
Precast Concrete Sheet Pile	360	l.f.	50.00	18,000
Rock Fill, Armor Stone	8,700	c.y.	6.00	52,000
Rock Bedding, Quarry Run	4,200	c.y.	4.00	17,000
Crushed Stone, Filter	1,500	c.y.	2.00	3,000
Drainage Modification	1	job	L.S.	3,000
				\$ 198,000
Contingencies				<u>39,000</u>
TOTAL COST - SAND HILL COVE STATE BEACH AND SAND HILL COVE				\$237,000
<u>ENTRANCE CHANNEL</u>				
Earth Excavation, Dredging	220,000	c.y.	(Included in cost of sand fill)	
<u>INNER HARBOR ANCHORAGE</u>				
Earth Excavation, Dredging	56,500	c.y.	(Included in cost of sand fill)	
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	54,000	c.y.	(Included in cost of sand fill)	
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	140,000	c.y.	(Included in cost of sand fill)	
<u>WAKEFIELD CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	85,000	c.y.	1.47	\$ 125,000
Contingencies				18,000
TOTAL COST - WAKEFIELD CHANNEL AND ANCHORAGE				\$ 143,000
<u>ADDITIONAL WAKEFIELD ANCHORAGE</u>				
Earth Excavation, Dredging	30,600	c.y.	1.47	\$ 45,000
Contingencies				7,000
TOTAL COST - ADDITIONAL WAKEFIELD ANCHORAGE				\$ 52,000

TABLE C-3 (continued)

ESTIMATED FIRST COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>LANDS AND DAMAGES</u>				
Lands in fee, Permanent Easements, Severance Damage, Improvements Temporary Rights				\$ 375,000 4,000 379,000
Contingencies				71,000
TOTAL COST - LANDS AND DAMAGES				\$ 450,000
<u>ENGINEERING AND DESIGN</u>				243,000
<u>SUPERVISION AND ADMINISTRATION</u>				290,000
SUBTOTAL - FIRST COST				\$3,565,000(1)
Navigation Aids				6,000
Preauthorization Survey Studies				44,000
Estimated First Cost to U.S.				\$2,413,600
Estimated First Cost to Local Interests				\$1,151,400

- (1) Does not include first cost of required local interests construction (self-liquidating) of \$310,000, of which \$250,000 is for beach facilities, \$40,000 is for public landings and \$20,000 is for spoil disposal areas.

TABLE C-4

ESTIMATED ANNUAL COSTS
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>		
Total Federal Investment Costs		\$2,463,600
<u>Federal Annual Costs</u>		
Interest on Investment, 2.625 percent		64,700
Amortization, 0.990 percent		24,400
Maintenance and Operation		
Dredging		
Entrance Channel	\$ 3,600	
Inner Harbor Anchorage	1,300	
Little Comfort Channel and Anchorage	6,000	
Snug Harbor Channel and Anchorage	1,500	
Wakefield Channel and Anchorage	1,000	
Additional Wakefield Anchorage	800	
Total Dredging	14,200	
Navigation Aids	600	
Total Maintenance and Operation	\$14,800	14,800
Total Federal Annual Costs		\$ 103,900
<u>Non-Federal Investment Costs</u>		
Contributed Funds		701,400
Lands and Damages		450,000
Total Non-Federal Investment Costs		\$1,151,400
<u>Non-Federal Annual Costs</u>		
Interest on Investment, 3.5 percent		40,300
Amortization, 0.763 percent		8,800
Maintenance and Operation		
Sand Replacement	\$51,400	
Rock Cover Replacement	5,000	
Embankment and General	4,600	
Concrete Features	500	
Fender Guide System	300	
Partial Gates	500	
Drainage	1,100	
Groins Repair	1,100	
Sand Fence Repair	100	
Total Maintenance and Operation	\$64,600	64,600

TABLE C-4 (continued)

Allowance for Major Replacements	
Partial Gates	\$1,200
Fender Guide System	600
Total Allowance for Major Replacements	<u>\$1,800</u> \$ 1,800
Total Non-Federal Annual Costs	115,500
TOTAL ANNUAL COSTS	\$219,400

TABLE C-5

ESTIMATED FIRST COSTS
(1961 Price Level)
WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>WAKEFIELD CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	85,000	c.y.	1.47	\$ 125,000
Contingencies				18,000
TOTAL COST - WAKEFIELD CHANNEL AND ANCHORAGE				\$ 143,000
<u>ADDITIONAL WAKEFIELD ANCHORAGE</u>				
Earth Excavation, Dredging	30,600	c.y.	1.47	\$ 45,000
Contingencies				7,000
TOTAL COST - ADDITIONAL WAKEFIELD ANCHORAGE				52,000
<u>ENGINEERING AND DESIGN</u>				6,000
<u>SUPERVISION AND ADMINISTRATION</u>				19,000
SUBTOTAL - FIRST COST				\$ 220,000(1)
Preauthorization survey studies				2,000
Estimated First Cost to U.S.				\$ 110,000
Estimated First Cost to Local Interests				\$ 110,000(1)

- (1) Does not include first cost of required local interests construction (self-liquidating) of \$20,000 for public landings.

TABLE C-6

ESTIMATED ANNUAL COSTS
(1961 Price Level)
WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs	\$ 112,000(1)
<u>Federal Annual Costs</u>	
Interest on Investment, 2.625 percent	3,000
Amortization, 0.990 percent	1,100
Maintenance and Operation	
Dredging	
Wakefield Anchorage and Channel	\$ 1,000
Additional Wakefield Anchorage	800
Total Dredging	\$ 1,800
Total Federal Annual Costs	5,900
<u>Non-Federal Investment Costs</u>	
Total Non-Federal Investment Costs	\$ 110,000
<u>Non-Federal Annual Costs</u>	
Interest on Investment, 3.5 percent	3,800
Amortization, 0.763 percent	900
Total Non-Federal Annual Costs	\$ 4,700
TOTAL ANNUAL COSTS	\$ 10,600

(1) Includes \$2,000 for preauthorization survey studies.

TABLE C-7

ESTIMATED FIRST COSTS SUMMARY
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Federal</u>	<u>Local</u>	<u>Total</u>
<u>WATER RESOURCES DEVELOPMENT</u>			
<u>PLAN, EXCLUDING WAKEFIELD</u>			
<u>CHANNEL AND ANCHORAGE</u>			
Construction	\$2,303,600	\$ 591,400	\$2,895,000
Lands and Damages		450,000	450,000
Subtotal - First Cost	2,303,600	1,041,400(1)	3,345,000(1)
Navigation Aids (2)	6,000		6,000
Preauthorization Survey Studies	42,000		42,000
Total Investment Cost	2,351,600	1,041,400	3,393,000
(From Table F-1)			
<u>WAKEFIELD CHANNEL AND ANCHORAGE</u>			
Construction	110,000	110,000	220,000
Subtotal - First Cost	110,000	110,000(3)	220,000(3)
Preauthorization Survey Studies	2,000		2,000
Total Investment Cost	112,000	110,000	222,000
(From Table C-3)			
<u>WATER RESOURCES DEVELOPMENT PLAN</u>			
Construction	2,413,600	701,400	3,115,000
Lands and Damages		450,000	450,000
Subtotal - First Cost	2,413,600	1,151,400(1,3)	3,565,000(1,3)
Navigation Aids (2)	6,000		6,000
Preauthorization Survey Studies	44,000		44,000
Total Investment Cost	2,463,600	1,151,400	3,615,000

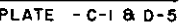
- (1) Does not include first cost of required local interests construction (self-liquidating) of \$290,000, of which \$250,000 is for beach facilities, \$20,000 is for public landings and \$20,000 is for spoil areas.
- (2) Installation by U.S. Coast Guard..
- (3) Does not include first cost of required local interests construction (self-liquidating) of \$20,000 for public landings.

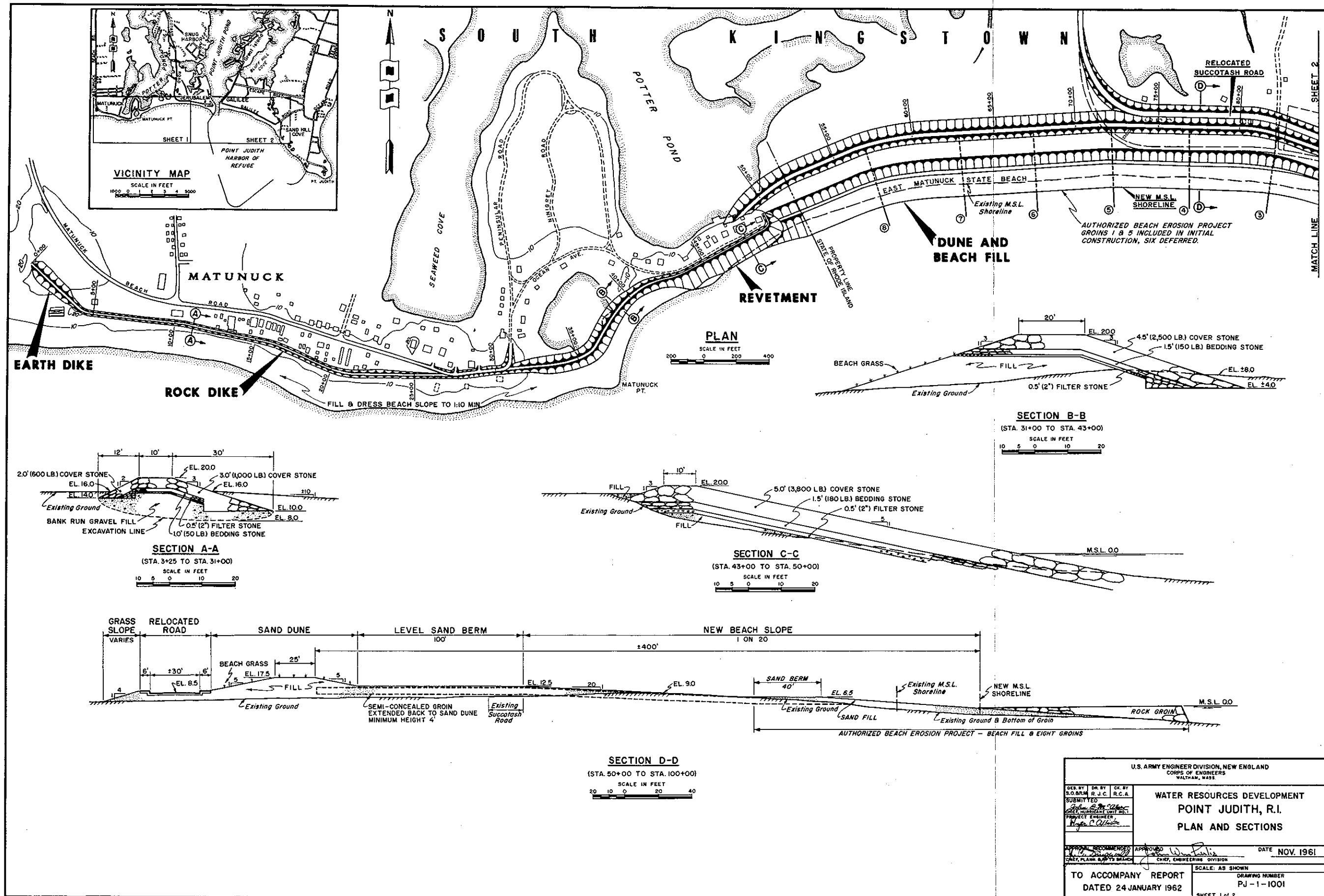
TABLE C-8

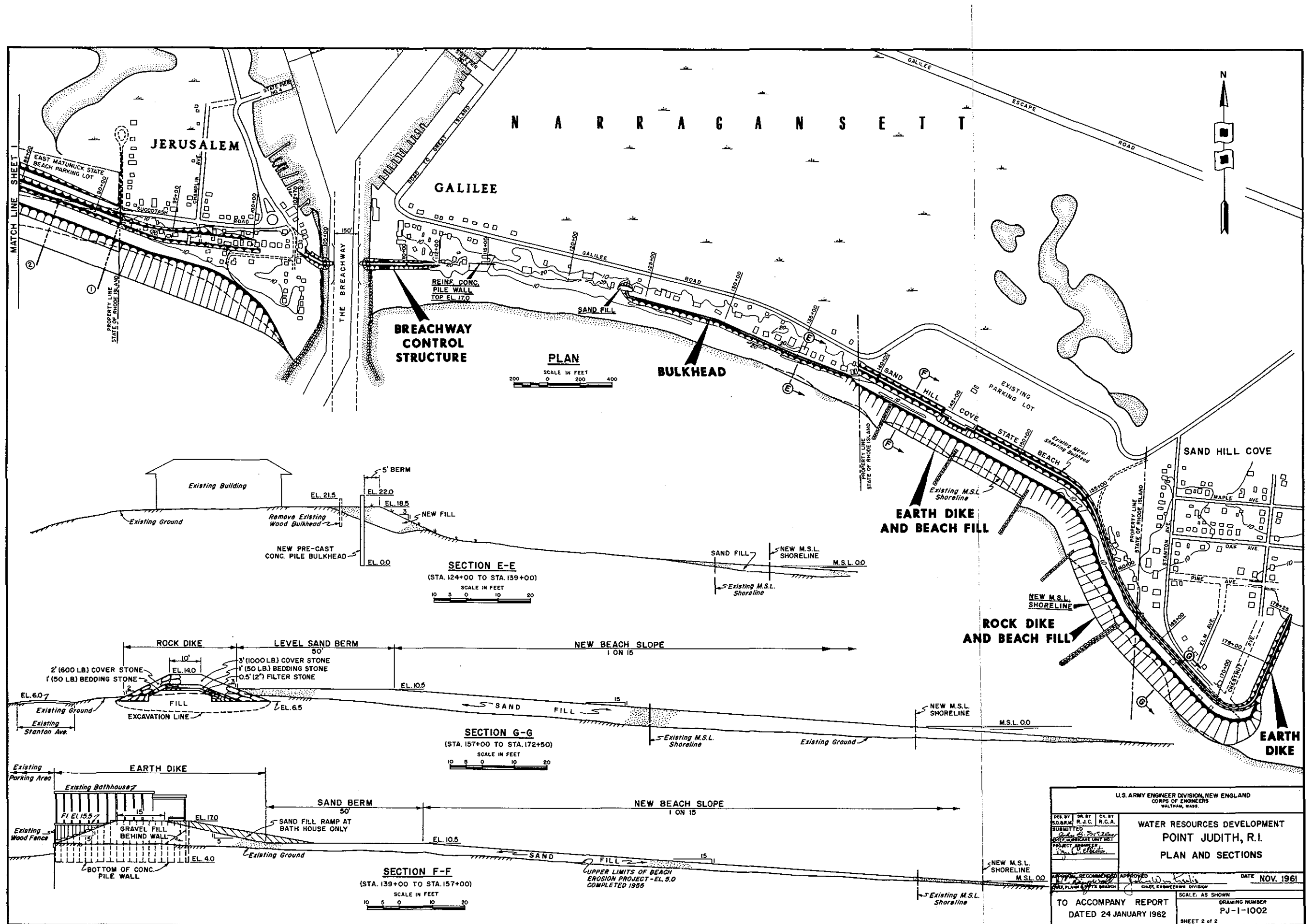
ESTIMATED ANNUAL COSTS SUMMARY
(1961 Price Level)
WATER RESOURCES DEVELOPMENT PLAN
POINT JUDITH, RHODE ISLAND

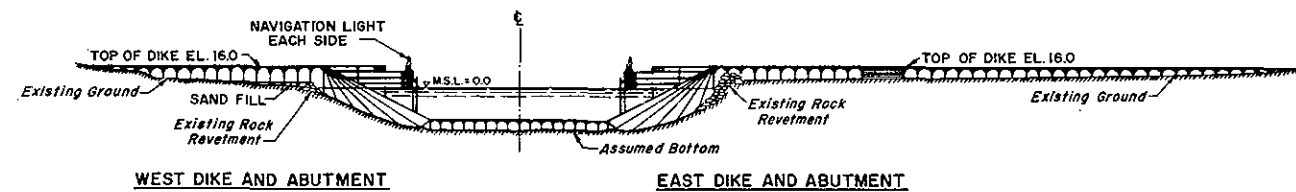
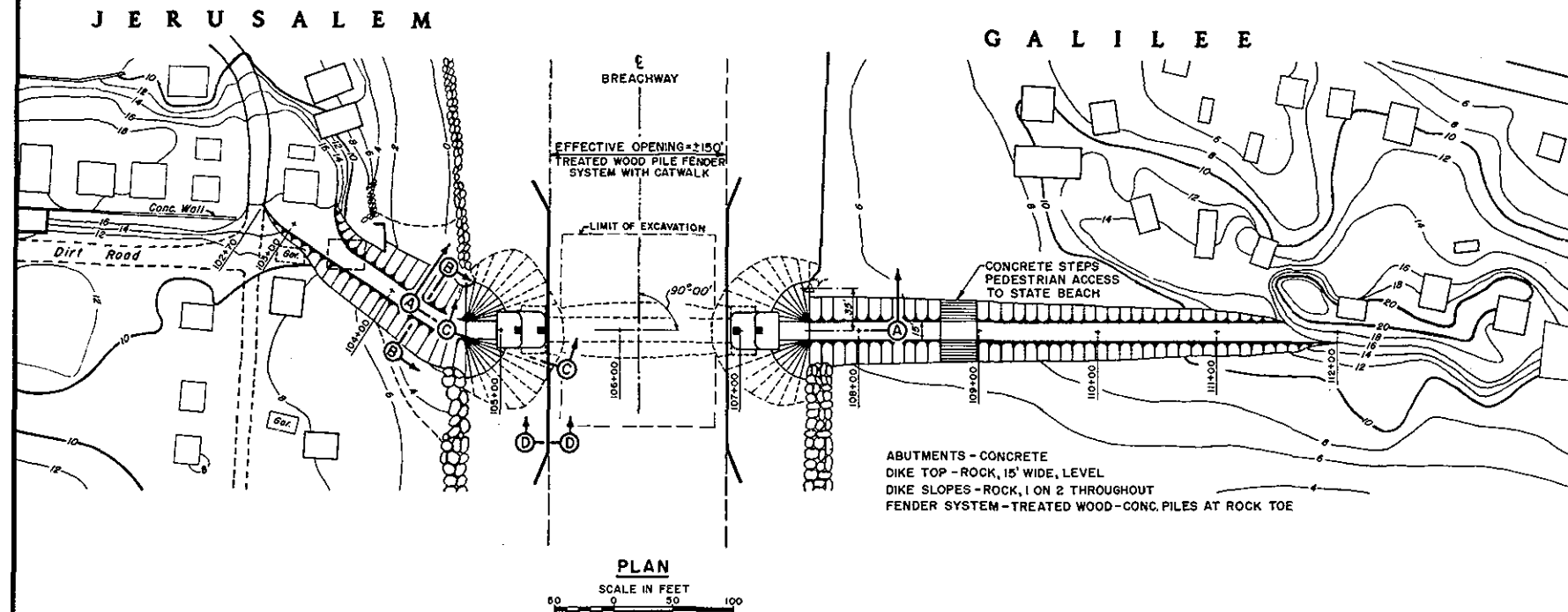
<u>Item</u>	<u>Federal</u>	<u>Local</u>	<u>Total</u>
<u>WATER RESOURCES DEVELOPMENT</u>			
<u>PLAN, EXCLUDING WAKEFIELD</u>			
<u>CHANNEL AND ANCHORAGE</u>			
Interest on Investment	\$ 61,700(1)	\$ 36,500	\$ 98,200
Amortization	23,300(2)	7,900	31,200
Maintenance and Operation	13,000(3)	64,600	77,600
Allowance for Major Replacements		1,800	1,800
Total Annual Costs	98,000(4)	110,800	208,800
(From Table F-23)			
<u>WAKEFIELD CHANNEL AND ANCHORAGE</u>			
Interest on Investment	3,000	3,800	6,800
Amortization	1,100	900	2,000
Maintenance and Operation	1,800		1,800
Total Annual Costs	5,900	4,700	10,600
(From Table C-4)			
<u>WATER RESOURCES DEVELOPMENT PLAN</u>			
Interest on Investment	64,700(1)	40,300	105,000
Amortization	24,400(2)	8,800	33,200
Maintenance and Operation	14,800(3)	64,600	79,400
Allowance for Major Replacements		1,800	1,800
Total Annual Costs	103,900(4)	115,500	219,400

- (1) Includes \$150 annual interest cost to U.S. Coast Guard.
 (2) Includes \$50 annual amortization cost to U.S. Coast Guard.
 (3) Navigation aids maintenance and operation to be provided by U.S. Coast Guard.
 (4) Includes \$800 annual costs to U.S. Coast Guard.

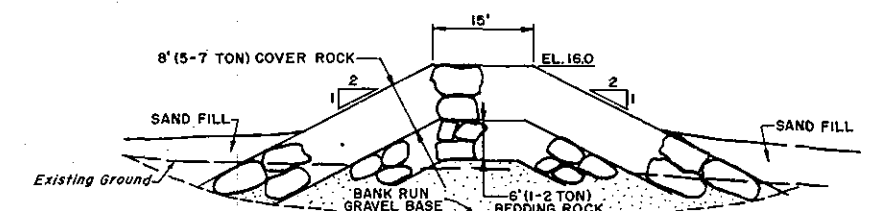
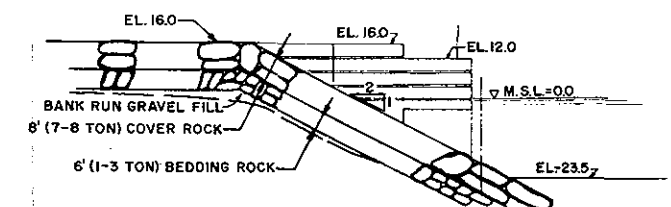
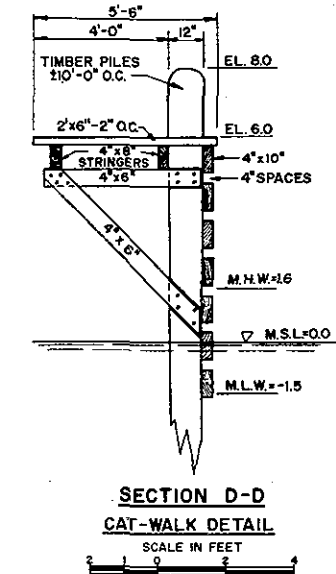
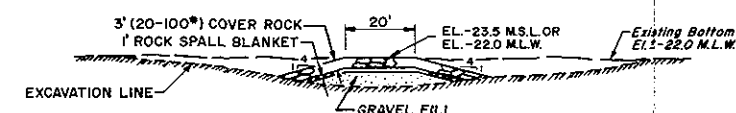
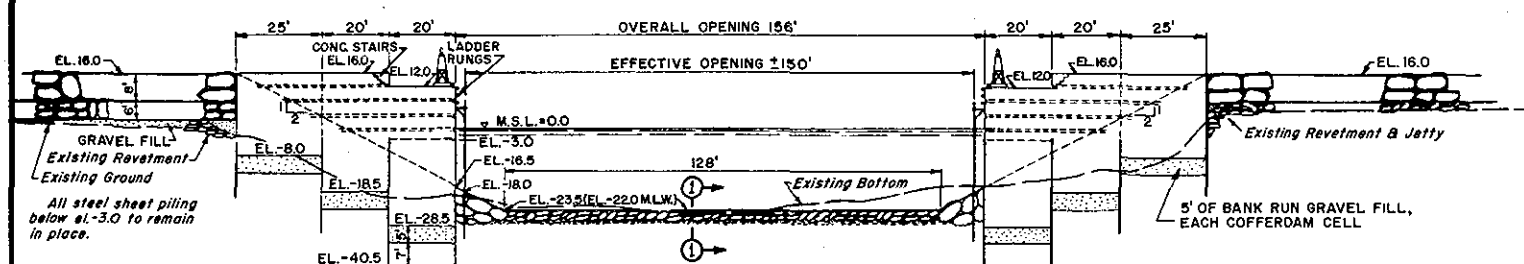






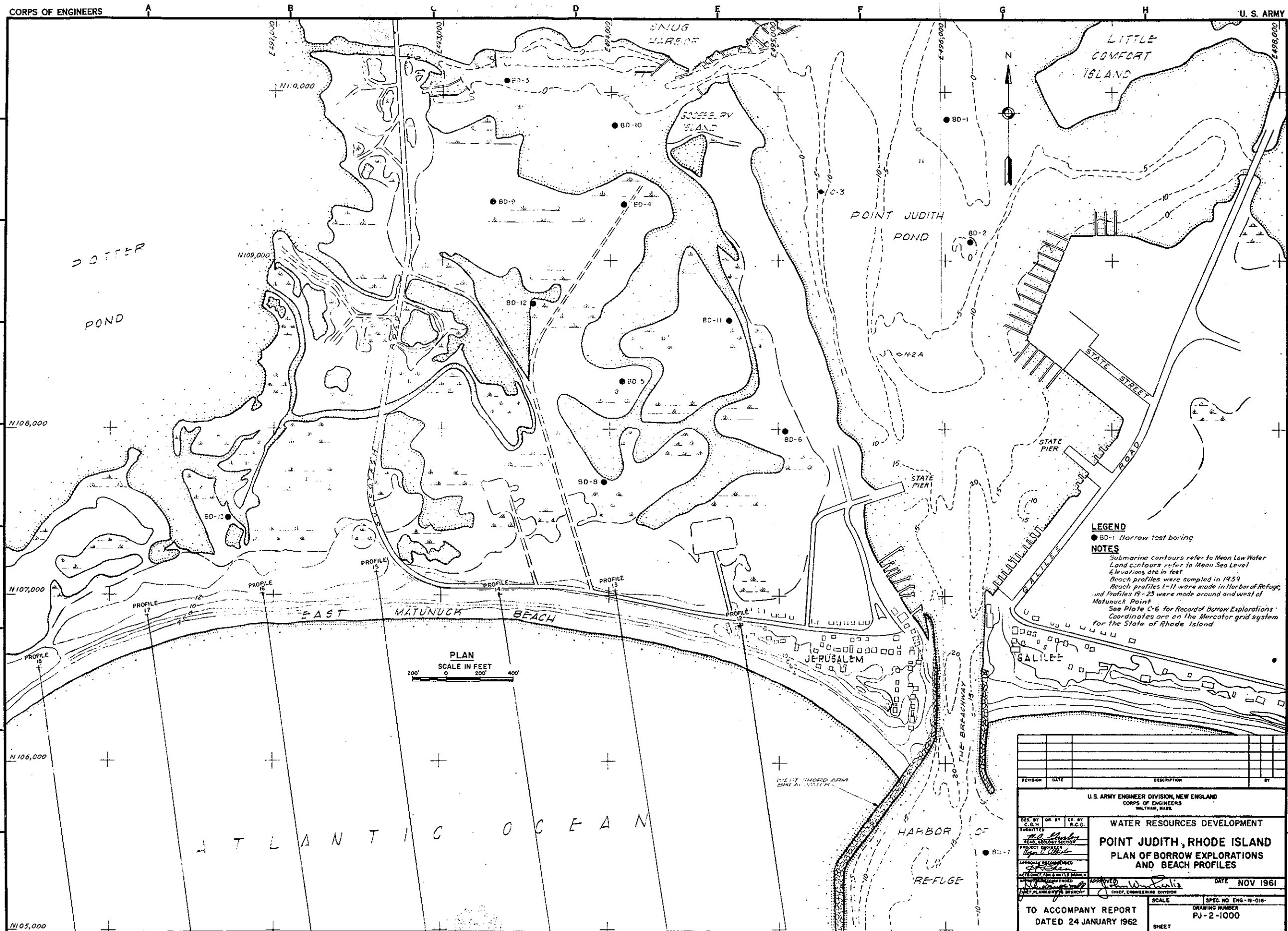


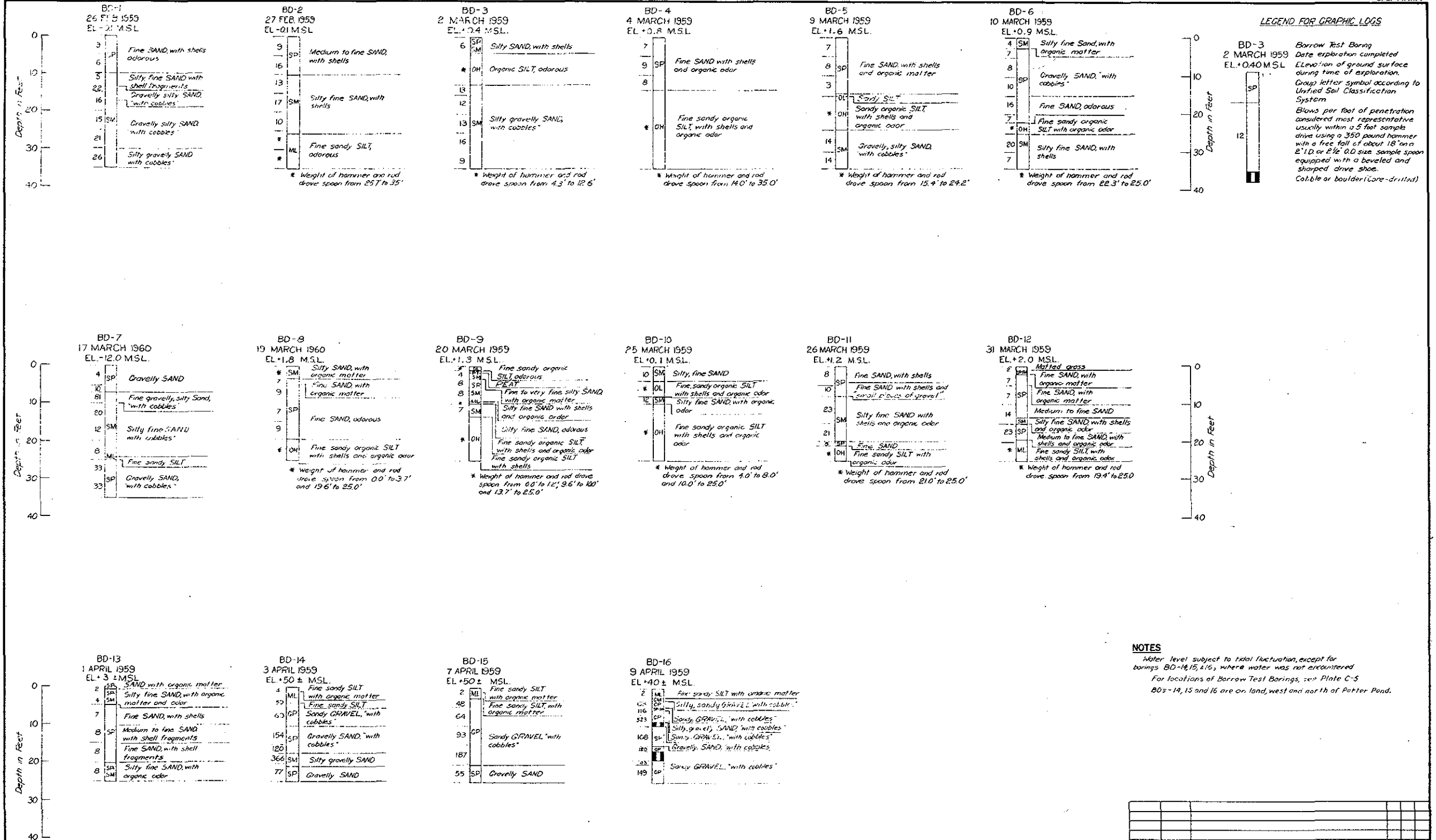
PROFILE
SCALE IN FEET
0 50 100



SECTION B-B
TYPICAL DIKE SECTION
SCALE IN FEET
0 10 20

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
DES. BY S.O. R.J.C. R.C.A.		SUBMITTED 24 JAN 1962	
PROJECT ENGINEER [Signature]		DATE NOV. 1961	
APPROVAL [Signature]		APPROVED [Signature]	
TO ACCOMPANY REPORT DATED 24 JANUARY 1962		DRAWING NUMBER PJ-1-1003	

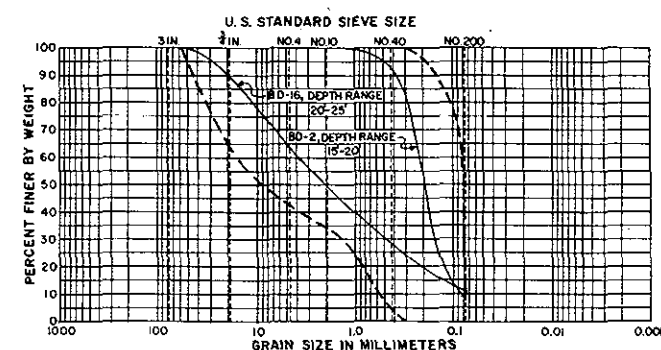




NOTES

Water level subject to tidal fluctuation, except for
borings BD-14, 15, & 16, where water was not encountered
For locations of Borrow Test Borings, see Plate C-5
BDs-14, 15 and 16 are on land, west and north of Potter Pond.

REVISION	DATE	DESCRIPTION	BY
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
DES BY: DR BY: CK BY:			
SUBMITTER: <i>W. C. Allen</i>			
PROJECT: <i>Point Judith, Rhode Island</i>			
APPROVED: <i>W. C. Allen</i>			
DATE: NOV 1961			
TO ACCOMPANY REPORT DATED 24 JANUARY 1962			
SHEET			



ENVELOPE OF GRADATION CURVES
(BORROW SAMPLES)

VARIATIONS IN GRAIN SIZE AT BEACH PROFILE STATIONS
(MEDIAN DIAMETER)

U. S. STANDARD SIEVE SIZE

3 IN
1 1/2 IN
NO. 4
NO. 10
NO. 40
NO. 200

PERCENT FINER BY WEIGHT

NO. 23 HIGH WATER
NO. 15 HIGH WATER

GRAIN SIZE IN MILLIMETERS

ENVELOPE OF GRADATION CURVES
(BEACH SAMPLES)

NOTE
Locations of Borrow Explorations and Beach Profiles
are shown on Plate C-5.

MEDIAN DIAMETERS OF BORROW SAMPLES

[illegible]

APPENDIX D
NAVIGATION
DESIGN STUDIES AND COST ESTIMATES

APPENDIX D

APPENDIX D

NAVIGATION

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
D-1	INTRODUCTION	D-1
D-2	PURPOSE AND EXTENT OF STUDY	D-1
D-3	DESCRIPTION OF NAVIGATION CONDITIONS	D-1
D-4	TRIBUTARY AREA	D-2
D-5	BRIDGES AFFECTING NAVIGATION	D-2
D-6	PRIOR REPORTS	D-2
D-7	EXISTING CORPS OF ENGINEER PROJECTS	D-4
D-8	LOCAL COOPERATION ON EXISTING AND PRIOR PROJECTS	D-5
D-9	OTHER IMPROVEMENTS	D-5
D-10	TERMINAL AND TRANSFER FACILITIES	D-5
D-11	IMPROVEMENTS DESIRED	D-6
D-12	EXISTING AND PROSPECTIVE COMMERCE	D-7
D-13	VESSEL TRAFFIC	D-7
D-14	DIFFICULTIES ATTENDING NAVIGATION	D-7
D-15	PLAN OF IMPROVEMENT	D-8
D-16	SHORELINE CHANGES	D-12
D-17	REQUIRED AIDS TO NAVIGATION	D-12
D-18	ESTIMATES OF FIRST COSTS	D-12
D-19	ESTIMATES OF ANNUAL CHARGES	D-13
D-20	ESTIMATES OF BENEFITS	D-15
	a. Commercial fishing	
	b. Recreational boating	

APPENDIX D (continued)

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
D-21	COMPARISON OF BENEFITS TO COSTS	D-19
D-22	PROPOSED LOCAL COOPERATION	D-19
D-23	APPORTIONMENT OF COSTS AMONG INTERESTS	D-19
D-24	COORDINATION WITH OTHER AGENCIES	D-20
D-25	DISCUSSION	D-21
D-26	ADDITIONAL NAVIGATION IMPROVEMENTS JUSTIFIED IN CONNECTION WITH HURRICANE PROTECTION WORKS	D-22
D-27	RECOMMENDATION	D-24
	<u>TABLES</u>	
<u>Number</u>		
D-1	Summary of Prior Navigation Reports	D-3
D-2	Summary of Prior Expenditures - Navigation	D-4
D-3	Benefit-cost Comparison - Plans of Navigation Improvement	D-9
D-4	First Costs - Plan of Navigation Improvements (Single Purpose)	D-13
D-5	First Costs and Annual Charges, Navigation Improvements (Single Purpose)	D-14
D-6	Annual Maintenance - Navigation Improvements (Single Purpose)	D-15
D-7	Recreational Benefits (Navigation)	D-17
D-8	Annual Benefits - Navigation Improvement (Single Purpose)	D-18
D-9	Recreational Benefits - Navigation Improvement (Single Purpose)	D-18

APPENDIX D (continued)

PLATES

Number

Title

D-1, D-2, Harbor of Refuge at Point Judith and
D-3 & D-4 Point Judith Pond

D-5 General Plan

TABLE F-17

ESTIMATED ANNUAL COSTS
(1961 Price Level)

HURRICANE PROTECTION, BEACH PROTECTION AND COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

Federal Investment Costs

Total Federal Investment Costs (From Table F-27)	\$ 2,322,400 (1)
---	------------------

Federal Annual Costs

Interest on Investment, 2.625%	61,000
Amortization, 0.990%	23,000
Maintenance and Operation	<u>4,200</u>
Total Federal Annual Costs	\$ 88,200

Non-Federal Investment Costs

Contributed Funds	495,600
Lands and Damages	<u>450,000</u>
Total Non-Federal Investment Costs (From Table F-27)	\$ 945,600

Non-Federal Annual Costs

Interest on Investment, 3.5%	33,100
Amortization, 0.763%	7,200
Maintenance and Operation	64,600 (2)
Allowance for Major Replacements	<u>1,800</u>
Total Non-Federal Annual Costs	\$ 106,700

TOTAL ANNUAL COSTS	\$ 194,900
--------------------	------------

- (1) Includes \$6,000 for navigation aids and \$39,000 for preauthorization survey studies.
- (2) Duplicates existing maintenance of approximately \$6,700.

APPENDIX D

NAVIGATION IMPROVEMENTS

DESIGN STUDIES AND COST ESTIMATES

D-1. INTRODUCTION

This appendix contains a detailed discussion of navigation improvements at Point Judith Harbor and Pond as a separate single purpose plan and also as part of a comprehensive plan of water resources development covering navigation, hurricane protection and beach erosion improvements. Existing navigation conditions, terminal facilities, commerce and vessel traffic and improvements desired and recommended are described. Estimates of cost, annual charges, benefits and benefit-cost ratios are given. Requirements of local cooperation, apportionment of costs, and coordination with other agencies are discussed.

D-2. PURPOSE AND EXTENT OF STUDY

This survey (review of reports) was made in compliance with a resolution adopted 1 July 1949 by the Senate Committee on Public Works to determine the advisability of modifying the existing navigation project for Point Judith Harbor and Pond. To this end, public hearings were held 17 December 1958 and 6 June 1960 in South Kingstown and Narragansett, Rhode Island, to obtain information on local desires for improvement; field investigations including hydrographic soundings and probings have been made; and available maps, statistics and other data have been studied. Various improvements have been investigated and engineering and economic estimates prepared. The need and economic justification for further Federal navigation improvements were analyzed and are discussed.

D-3. DESCRIPTION OF NAVIGATION CONDITIONS

Point Judith Harbor of Refuge is an artificial harbor formed by three Federal breakwaters that shelter an area of 770 acres, including 200 acres, 24 to 30 feet deep. There are no terminal facilities of any kind in the Harbor of Refuge.

Point Judith Pond is a tidal lagoon connected to the Harbor of Refuge by a Federal channel 15 feet deep which extends to terminal facilities just north of "The Breachway" through the barrier beach. The Pond, dotted with islands and shoals, extends about 4 miles north to Wakefield and is about one mile wide. Natural depths average about 3 feet and are generally less than 8 feet. A Federal channel, 6 feet deep, has been dredged to the docks at Wakefield. The mean tide range is 3.1 feet in the Harbor of Refuge, 3.0 feet in the Pond near the Breachway, and 2.9 feet at Wakefield at the head of the Pond. Maximum tidal currents are less

than 1 knot in the entrances to the Harbor of Refuge between the breakwaters, but average 2.9 knots on the flood and 2.7 knots on the ebb through the entrance to Point Judith Pond.

D-4. TRIBUTARY AREA

The immediate area tributary to Point Judith Pond consists of the towns of Narragansett on the east and South Kingstown on the west. Both towns are pleasant residential and farming communities that depend to a considerable degree on the visitors attracted by the recreational facilities of the area. Recreational boating and sport fishing facilities attract enthusiasts from a large area of southern New England. The commercial fishing industry at Point Judith is the largest in the State. The Harbor of Refuge serves the coastal traffic traveling between Long Island Sound and Narragansett Bay.

D-5. BRIDGES AFFECTING NAVIGATION

The only outlet to Potter Pond, a tidal lagoon lying west of Point Judith Pond, is a shallow channel south of Snug Harbor. This channel is crossed by the only highway access to Jerusalem. The fixed timber bridge has a vertical clearance of 5 feet above mean high water. The tide range at the bridge is about 1.5 feet. This bridge limits boat traffic between the Ponds to small open outboard boats for which the natural channel depth of about 2 feet is adequate.

Great Island, on the east side of Point Judith Pond, is connected to Galilee by a fixed highway bridge with a horizontal clearance of 25 feet and a vertical clearance of 12 feet at mean high water; the tide range at the bridge is 3.0 feet. The waterway under the bridge has been dredged by the State to a depth of 8 feet but vessel traffic under the bridge is limited by natural water depths of about 1 foot in Bluff Hill Cove north of the bridge.

The Saugatuckett River, which flows into the head of Point Judith Pond at Wakefield, is to be crossed by U.S. Route 1 on a fixed bridge with a horizontal clearance of 30 feet and a vertical clearance of 24 feet. There is no navigation use above this point and the natural channel depth under the bridge is about 1 foot.

D-6. PRIOR REPORTS

The report under review was a favorable survey report published in Senate Document Number 15, 80th Congress, 1st Session in 1947. This report resulted in the authorization in 1948 of the 15-foot and 6-foot channels and the 10-foot anchorage. Other prior reports are listed in Table D-1.

TABLE D-1
SUMMARY OF PRIOR NAVIGATION REPORTS
POINT JUDITH AREA

Year	Nature and Part Considered	Recommendation	Published in -				
			H. Doc.			Annual Report of Chief of Engineers	
			No.	Cong.	Sess.	Year	Page
1873	Survey on pond	Unfavorable	84	43	1	1874	II, 286
1888	Preliminary on pond	do				1889	642
1888	Preliminary on harbor	Favorable	66	51	1	1890	592
1889	Survey on harbor	do ⁽¹⁾	66	51	1	1890	594
1893	Preliminary on pond	Unfavorable				1893	877
1895	Survey on pond	do				1895	689
1897	Survey on harbor	do	53	55	1	1897	937
1897	Survey on pond	do	132	55	2	1898	935
1903	Examination on harbor and pond	(1)(2) Favorable	60	58	2	1904	949
1908	Survey on harbor	do ⁽¹⁾	911	60	1		
1909	Preliminary on pond	Unfavorable	79	61	1		
1916	do	do	788	64	1		
1917	Preliminary on shoal in harbor	(1) Favorable	2001	64	2		
1926	Preliminary on pond	Abandonment	467	69	1		
1933	Preliminary on harbor and pond	Unfavorable	(3)	(3)	(3)	(3)	(3)
1933	Preliminary on pond	do ⁽¹⁾ (2)	(3)	(3)	(3)	(3)	(3)
1946	Review report on harbor and pond	Favorable	15(4)	80	1		

- (1) Basis of existing project for harbor.
(2) Basis of existing project for entrance to pond
(3) Not published.
(4) Senate document

D-7. EXISTING CORPS OF ENGINEERS PROJECT

The existing Federal navigation project for Point Judith Harbor and Pond was authorized by Congressional Acts in 1890, 1907, 1910, 1919, and 1948. The improvement for the Harbor of Refuge consists of a main breakwater 6,970 feet long, roughly V-shaped with its apex about 1.2 miles offshore; an easterly shore arm breakwater 2,240 feet long; a westerly shore arm breakwater 3,640 feet long; and removal of two shoals in the anchorage to a depth of 18 feet.

The improvement for Point Judith Pond consists of a channel into Point Judith Pond, 15 feet deep and 150 feet wide, between the jetties at the Breachway extending on the west side of the pond to a point 100 feet north of the State pier at Jerusalem, with a branch channel, 15 feet deep and 200 feet wide, on the east side of the pond extending to a point 100 feet north of the State pier at Galilee; an anchorage basin just inside the entrance, 10 feet deep with an area of about 5 acres; a sand arresting structure consisting of an impermeable core at the shore end of the west breakwater; a channel, 6 feet deep and 100 feet wide, from the 15-foot west branch to the head of the Pond at Wakefield with an anchorage basin 6 feet deep and about 5 acres in area at the upper end.

The existing project was completed in 1950. The total costs under the existing project from Federal regular funds have been \$3,567,715 of which \$2,488,430 was for new work and \$1,079,285 was for maintenance. In addition, the sum of \$17,587 was expended from non-Federal contributed funds for new work. The breakwaters were last maintained in 1951 and are now in need of repair. The channels were last maintained in 1959.

Table D-2 gives a summary of expenditures for the breakwater and the channels and anchorages.

TABLE D-2

SUMMARY OF PRIOR EXPENDITURES - NAVIGATION

POINT JUDITH AREA

<u>Description</u>	<u>New Work</u>	<u>Maintenance</u>	<u>Total</u>
Breakwaters	\$2,390,783	\$ 877,446	\$3,268,229
Channels & anchorages	<u>109,647 *</u> \$2,500,430	<u>201,839</u> \$1,079,285	<u>311,486 *</u> \$3,579,715

* Includes \$12,000 for channel improvement under previous project, since abandoned. Does not include \$17,587 from contributed funds for new work.

D-8. LOCAL COOPERATION ON EXISTING AND PRIOR PROJECTS

No conditions of local cooperation were prescribed in connection with Federal projects for improvement of Point Judith Harbor and Pond prior to 1948. All requirements of local cooperation since then have been fully complied with. These requirements provided that prior to construction of the 6-foot channel and basin local interests contribute 50 percent of the first cost of these improvements, but not to exceed \$30,000; and that no work be undertaken until local interests agree to

a. Repair and stabilize the outer 450 feet of the State bulkhead along the entrance and maintain the bulkhead and State piers,

b. Furnish free of cost to the United States all lands, easements, rights-of-way and suitable spoil disposal areas for the new work and subsequent maintenance as and when required.

c. Hold and save the United States free from damages due to the improvements.

D-9. OTHER IMPROVEMENTS

About 1902 the State and the town of South Kingstown dredged a channel about 7 feet deep through the beach which then separated Point Judith Pond from the Harbor of Refuge and constructed short stone jetties at this entrance to the pond at a total cost of \$44,243. A Federal project for the entrance to Point Judith Pond, adopted in 1905 and since abandoned provided for extension of the jetties or dredging as the Secretary of War may deem most beneficial in furtherance of the work done by these local interests. Under this project the west jetty was extended inland a short distance to protect its shore end. This project was completed in 1906 at a cost of \$12,000 all for new work. In 1934 and 1935 the State expended a Federal PWA grant of \$77,000 and \$227,281 of State funds in extending and rebuilding the east jetty; dredging a basin of about 35 acres to a depth of 12 feet just inside the entrance; construction of State piers on the basin, one at Galilee and one at Jerusalem; bulkheading along the basin; and dredging a channel 8 feet deep and 300 feet wide for a few thousand feet north from the basin along the west side of the pond and thence 6 feet deep and 100 feet wide to Wakefield. Later the State repaired the east jetty and bulkhead at a cost of \$19,101.

D-10. TERMINAL AND TRANSFER FACILITIES.

The water-terminal facilities are all within the pond and are concentrated at three locations, Galilee-Jerusalem, Snug Harbor and Wakefield. The State installations in the Galilee-Jerusalem area make up a large portion of the terminal facilities and include State

Pier No. 4 in Jerusalem, State Pier No. 3 in Galilee and about 40 State finger piers in Galilee. The U.S. Coast Guard boathouse and pier are also in Galilee. In all, about 120 craft up to 70 feet in length can be accommodated. The commercial fishing vessels use the area south of the fish dehydrating plant in Galilee and for the most part the sport fishing craft use the newer finger piers north of the plant. Other facilities in the Galilee-Jerusalem area include fueling docks servicing local and transient boats and private docks accessible to the larger craft only at high tide. State Pier No. 3 in Galilee is the mainland terminus for ferry service to Block Island, about 12 miles offshore. At Snug Harbor there are marine supply stores, and repair and storage facilities capable of accommodating the larger commercial and recreational craft. Other smaller recreational boat facilities are located in the Potter Pond Channel. At the head of the pond there are several yacht clubs and marinas providing mooring facilities and open storage for small boats, and a marine railway operation capable of handling boats up to five feet in draft and providing mooring, storage and repair facilities.

D-11. IMPROVEMENTS DESIRED

At public hearings local interests have requested improvements in the existing Federal navigation project at Point Judith Harbor and Pond as follows:

- a. repair of the breakwaters forming the Harbor of Refuge,
- b. straighten the entrance channel to Point Judith Pond and deepen it from 15 feet to 20 feet,
- c. provide a bulkhead along the shore between State Pier No. 4 (Jerusalem) and Gooseberry Island,
- d. extend the existing anchorage area opposite State Pier No. 3 (Galilee) to a line between Potter Pond Channel and Little Comfort Island,
- e. provide a protected mooring basin of about 35 acres adjacent to Potter Pond Channel,
- f. deepen the existing channel to Wakefield from 6 feet to 12 feet and widen it from 100 feet to 150 feet and investigate the possibility of relocating it in the center of the pond,
- g. enlarge and deepen the anchorage area at Wakefield,
- h. provide a navigation channel Long Cove to Champlin Cove with suitable bridge at the causeway separating the two coves.

Local interests also requested a study of the possibility of combining navigation improvements in the area with hurricane protection.

D-12. EXISTING AND PROSPECTIVE COMMERCE

The commercial fishing industry has flourished in Point Judith Pond to the extent that in 1957 about 120,000,000 pounds of industrial fish and about 10,000,000 pounds of edible fish with a total value of about \$1,860,000 were landed. Comparable figures for 1959 were 91,000,000 pounds and 11,000,000 pounds for industrial and edible fish, respectively. Due to cutbacks in poultry production and competition from foreign fish meal imports, the 1960 landings of industrial fish were about 40,000,000 pounds with landing of edible fish being about 13,000,000 pounds. A determined effort is being made to restore the landings of industrial fish to previous levels.

Local interests estimate that 15 additional commercial fishing craft averaging 60 feet in length would use Point Judith Pond as a home port and an additional 20 transient boats would use the harbor if the entrance channel were improved.

D-13. VESSEL TRAFFIC

Point Judith Pond is the mainland terminus of a ferry to Block Island, Rhode Island, that carried 76,600 passengers and 4,700 automobiles in 1958. Reported vessel traffic in 1958 was 5,500 inbound and 5,500 outbound trips. Of the foregoing, 916 inbound trips and 366 outbound trips were made by vessels drawing 9 feet or more.

In addition to the above, the recreational fleet permanently berthed in Point Judith Pond has grown to over 2,000 boats. Hundreds of others stop there each year, including about 150 large power cruisers that come for the annual Atlantic Tuna Tournament held at Galilee. A large number of charter boats for recreational fishing parties and cruises operate from Galilee.

D-14. DIFFICULTIES ATTENDING NAVIGATION

The navigational difficulties in Point Judith Pond are the result of recently increased boating and vessel traffic, tidal currents in the entrance channel through the Breachway, inadequate depths in existing channels and anchorages and insufficient mooring space. The tidal currents encountered in the channel approach to Point Judith Pond cause vessels to set toward the edge of the channel when making the final turn into the Breachway.

The Block Island ferry has had several groundings at this point. Any shoaling at this bend forces vessels closer to the west arm of the Breakwater making the turn more hazardous. The existing channels within the pond do not allow the larger boats access to the

boatyards at the head of the pond. Additional anchorage and deeper channels would allow recreational craft to more fully use the harbor and its facilities.

D-15. PLAN OF IMPROVEMENT

All the requests for navigation improvements by local interests have been considered. Repair and rehabilitation of the breakwaters forming the Harbor of Refuge is to be accomplished under existing authority. The desired bulkhead along the west shore of the pond between the State pier at Jerusalem and Gooseberry Island is not essential to navigation and is considered to be a local responsibility. A 35-acre mooring basin adjacent to Potter Pond Channel does not appear to be essential for navigation at this time. The requested channel improvement and bridge at Long Cove-Champlin Cove is not essential and is considered a matter of local responsibility. All of the other requests of local interests were considered in detail. They include anchorages and channels for small boats at Wakefield and Snug Harbor, improvements in the entrance channel, and an additional anchorage area in lower Point Judith Pond. Estimates of first cost, annual costs, benefits and benefit-cost ratios for all of the possibilities considered are shown in Table D-3.

TABLE D-3

BENEFIT-COST COMPARISONPLANS OF NAVIGATION IMPROVEMENTPOINT JUDITH AREA

Description	Vol. in 1000 Cu.Yd.	Thousands of Dollars			B/C Ratio
		First Cost*	Annual Costs *	Annual Benefits	
Deepen the existing entrance channel to Point Judith Pond from 15 to 20 feet at m.l.w.	155.0	290.0	12.4	22.3	1.8
Deepen the existing entrance channel to Point Judith Pond from 15 to 18 feet at m.l.w.	80.0	150.0	6.1	14.0	2.3
Dredge an access channel to the State finger piers 150 feet wide and 10 feet deep at m.l.w.	4.0	8.0	4.3	7.8	1.8
Enlarge the existing anchorage at Galilee to include an additional 6 acres, 10 feet deep	6.5	12.0	1.0	1.2	1.2
Dredge an 8-acre anchorage 8 feet deep at Galilee South of Little Comfort Island	50.0	90.0	5.5	10.1	1.8

Table D-3 (cont.)

Description	Vol. in 1000 Cu. Yd.	Thousands of Dollars			B/C Ratio
		First Cost*	Annual Costs*	Annual Benefits	
Dredge the shoal area between Little Com- fort Island and Potter Pond Channel to a depth of 12 ft. (40 acres)	650.0	1220.0	48.8	13.7	0.3
Deepen existing chan- nel to Wakefield to following dimensions and deepen existing anchorage to same depth					
<u>100 x 8 feet</u>	85.0	160.0	7.4	11.0	1.5
" <u>100 x 10 feet</u>	200.0	380.0	16.5	13.0	0.8
" <u>100 x 12 feet</u>	400.0	750.0	31.5	13.0	0.4
" <u>150 x 8 feet</u>	165.0	310.0	13.2	12.0	0.9
" <u>150 x 10 feet</u>	350.0	660.0	27.5	14.0	0.5
" <u>150 x 12 feet</u>	690.0	1300.0	53.2	14.0	0.3
" <u>150 x 6 feet</u>	15.0	30.0	1.6	1.0	0.6
Relocate channel to Wakefield to center of Pond at following dim- ensions, and deepen the existing anchorage to the same depth					
<u>100 x 8 feet</u>	130.0	240.0	10.4	11.0	1.1
<u>100 x 10 feet</u>	250.0	470.0	20.0	13.0	0.7
<u>100 x 12 feet</u>	450.0	840.0	35.1	13.0	0.4
<u>150 x 8 feet</u>	230.0	430.0	17.9	12.0	0.7
<u>150 x 10 feet</u>	390.0	730.0	30.3	14.0	0.5
<u>150 x 12 feet</u>	770.0	1440.0	58.7	14.0	0.2
<u>150 x 6 feet</u>	35.0	66.0	3.1	1.0	0.3
Dredge an anchorage at Snug Harbor of 5 acres, 6 feet deep with an access channel 100 feet wide and 6 feet deep	105.0	200.0	9.2	10.5	1.2

Table D-3 (cont.)

Description	Vol. in 1000 Cu.Yd.	Thousands of Dollars			B/C Ratio
		First Cost*	Annual Costs*	Annual Benefits	
Dredge an anchorage at Snug Harbor of 5 acres, 8 feet deep with an access channel 100 feet wide and 8 feet deep	140.0	260.0	11.8	11.5	0.9
Dredge an additional anchorage area at Wakefield of 7 acres, 8 feet deep	30.0	60.0	3.1	4.0	1.3

* Exclusive of Preauthorization Study Cost

In view of the data in Table D-3, the following items appear to be feasible when considered from an economic standpoint and are therefore included in the plan of navigation improvements.

a. Deepen the existing entrance channel to 20 feet at mean low water.

b. Enlarge the existing anchorage at Galilee (Inner Harbor Anchorage) to provide an additional 6 acres 10 feet deep at mean low water.

c. Provide an 8-acre anchorage (Little Comfort Anchorage) 8 feet deep at mean low water between Galilee and Little Comfort Island.

d. Provide an access channel along the State finger piers 150 feet wide and 10 feet deep at mean low water, to the Little Comfort anchorage.

e. Provide a 5-acre anchorage (Snug Harbor Anchorage) 6 feet deep at mean low water and an access channel thereto 100 feet wide and 6 feet deep at mean low water in the Potter Pond Channel south of Snug Harbor.

f. Deepen the existing 100-foot wide channel to Wakefield and the existing anchorage there from 6 feet to 8 feet at mean low water.

g. Enlarge the existing anchorage at Wakefield to provide an additional 7 acres, 8 feet deep at mean low water.

Additional navigational improvements would be justified if undertaken concurrently with hurricane protection and beach protection measures. Dredging for beach and dike fill at certain locations could provide navigation benefits without added cost. These improvements include: (1) relocating the entrance channel in a straight line outside the Breachway 150 feet wide and 20 feet deep; (2) providing deeper and larger anchorages inside the Breachway and at Snug Harbor. These possibilities are evaluated in Paragraph D-26. Future channel maintenance would be reduced by overdredging both in width and depth depending upon the amount of material required for the hurricane and beach protection improvements.

D-16. SHORELINE CHANGES.

The plan of improvement involves dredging of channels and anchorages within the enclosed pond and in the entrance channel thereto. It is not considered that this work would have any significant effect on the adjacent shorelines.

D-17. REQUIRED AIDS TO NAVIGATION

The U.S. Coast Guard has been consulted and has reported that no additional aids to navigation would be required as a result of the proposed navigation improvements.

D-18. ESTIMATES OF FIRST COSTS

The cost estimates provide for dredging to the proposed project depths plus an allowance of one foot for overdepth, with side slopes of 1 vertical on 3 horizontal. The costs include an allowance for contingencies and are based on June 1961 prices for removal of material by contract dredging. The estimate is based on use of a hydraulic dredge and spoil disposal on nearby land areas. The estimated first cost of the plan of improvement described in Par. D-25 is \$828,000 including \$8,000 for preauthorization studies. The costs of the individual features of the plan of improvement are in Table D-4.

TABLE D-4

FIRST COSTSPLAN OF NAVIGATION IMPROVEMENTS (SINGLE PURPOSE)POINT JUDITH AREA

<u>Improvement</u>	<u>First Cost</u> (1961 Price Level)
Entrance Channel	\$290,000
Inner Harbor Anchorage, add'l 6 acres	12,000
Little Comfort Anchorage	90,000
Channel to Little Comfort Anchorage	8,000
Snug Harbor Channel and Anchorage	200,000
Wakefield Channel and Anchorage	160,000
Wakefield Anchorage, add'l 7 acres	60,000
Total	<u>\$820,000</u>
Preauthorization Studies	<u>\$ 8,000</u>
Total	<u>\$828,000</u>

D-19. ESTIMATES OF ANNUAL CHARGES

Annual charges for construction of the improvements are based on an interest rate of 2.625 percent for Federal, 3.5 percent for non-Federal investment, and a project life of 50 years. The cost of deepening the entrance channel, being in the interest of commercial navigation, would be borne entirely by the Federal Government. The costs of all the other features of the plan would be shared equally by Federal and non-Federal interests. See Table D-5 for breakdown of First Costs and Annual Charges.

TABLE D-5

FIRST COSTS AND ANNUAL CHARGESNAVIGATION IMPROVEMENTS (SINGLE PURPOSE)POINT JUDITH AREA

<u>Improvement</u>	<u>First Cost</u>		<u>Annual Charges</u>	
	<u>Federal*</u>	<u>non-Federal</u>	<u>Federal</u>	<u>non-Federal</u>
Entrance Channel	\$293,000	-	\$ 12,400	-
Inner Harbor Anchorage, add'l 6 acres	6,000	6,000	700	300
Little Comfort Anchorage	46,000	45,000	3,600	1,900
Channel to Little Comfort Anchorage	4,000	4,000	4,100	200
Snug Harbor Channel and Anchorage	102,000	100,000	4,900	4,300
Wakefield Channel and Anchorage	82,000	80,000	4,000	3,400
Wakefield Anchorage, add'l 7 acres	30,000	30,000	1,900	1,200
TOTALS	<u>\$563,000</u>	<u>\$265,000</u>	<u>\$31,600</u>	<u>\$11,300</u>

*Preauthorization studies included.

The above Federal annual charges include additional maintenance of the channels and anchorages totaling \$11,300 annually based on experience in the area as outlined in Table D-6.

TABLE D-6

ANNUAL MAINTENANCENAVIGATION IMPROVEMENTS (SINGLE PURPOSE)POINT JUDITH AREA

<u>Improvement</u>	<u>Cu. Yd.</u>	<u>Unit Price</u>	<u>Cost</u>
Entrance Channel	900	\$2.00	\$ 1,800
Inner Harbor Anchorage, add'l 6 acres	250	2.00	500
Little Comfort Anchorage	1,000	2.00	2,000
Channel to Little Comfort Anchorage	2,000	2.00	4,000
Snug Harbor Channel and Anchorage	600	2.00	1,200
Wakefield Channel and Anchorage 8'	500	2.00	1,000
Wakefield Anchorage, add'l 7 acres	400	2.00	800
TOTAL	<u>5,650</u>		<u>\$ 11,300</u>

D-20. ESTIMATES OF BENEFITS

The considered improvements in Point Judith Harbor and Pond would result in immediate benefits to the fishing and recreational fleets based in the pond as well as to vessels that visit the area. The benefits to commercial fishing have been evaluated in terms of the additional catch resulting from the improvements. Recreational benefits are evaluated in terms of increased use by the owners of the boats of the present and reasonably prospective fleet. Benefits have been computed for each individual feature of the overall plan of improvement.

a. Commercial fishing. It is considered that additional fishing boats would be attracted to Point Judith Pond if the entrance channel were deepened to 20 feet. The U.S. Fish and Wildlife Service has estimated that one fishing boat would be newly purchased as a result of the improvement, and that it would make an estimated 156 trips per year with each trip providing a catch valued at \$130, resulting in a

gross annual catch of \$20,300. With operating costs of 60 percent of the value of the catch, the net return to the fishermen is estimated at \$8,100. In addition, 34 boats would be transferred from other harbors and therefore be able to make 4 additional trips per year due to the time saved in travelling to and from the fishing grounds. This would result in 136 additional trips per year with an average catch value of \$130, for a gross annual catch value of \$17,700. It is estimated that there would be only a slight increase in operating costs to make these additional trips resulting in about 80% return to the fishermen. The net value of the additional catch by transferred boats would then be \$14,200 resulting in a total benefit of \$22,300 annually if the entrance channel were deepened to 20 feet.

If the channel were only deepened to 18 feet the Fish and Wildlife service estimates that only 14 boats would transfer to Point Judith Pond and one would be newly purchased. The 14 transferred boats would make 4 additional trips each for a total of 56 trips at \$130 per trip for a gross increase in catch value of \$7300.00. At 80% return to the fishermen this equals about \$5900 net annual return. The newly purchased boat would net \$8100 annually as described above resulting in a net annual benefit of \$14,000.

b. Recreational boating. The benefits accruing to the existing pleasure fleet are considered to be the increased annual net return of the boats to the owners. The annual net return to the owners has been taken as the amount the owners would receive if they chartered to others, this amount having been computed at various percentages of the present depreciated boat value for various classes of boats, in accordance with available studies of boating practice. In view of the present congestion in the pond it is considered that the owners now receive only 80 to 90 percent of the return possible under ideal conditions. It is estimated that construction of the plan of improvement would increase the return to 100 percent as well as attract additional craft to the area. Each feature of the plan has been considered separately and the benefits accruing to each feature are shown in Table D-7. The table shows the number of boats using each feature and the value of the increased annual return to the boat owners as a result of the improvement. This increased annual return represents the annual benefit.

TABLE D-7

RECREATIONAL BENEFITS (NAVIGATION)POINT JUDITH AREA

Improvement	No. of Boats	New (N) Or Existing (E)	Depreciated Value		P e r c e n t R e t u r n				Value
			Ave.	Total	Ideal	% of Ideal	Gain		
						Present	Future		
Inner Harbor Anchorage, additional 6 acres	30	E	5000	150,000	8	90	100	0.8	\$1200
Little Comfort Anchorage	30	E	4000	120,000	8	80	100	1.6	1900
	10	N	4000	40,000	8	0	100	8.0	3200
	40	N*	4000	160,000	8	0	100	8.0*	5000*
Channel to Little Comfort Anchorage	500	E	5000	2,500,000	8	**	**	**	7800**
Snug Harbor Channel	25	E	3000	75,000	10	80	100	2.0	1500
	10	N	5000	50,000	10	0	100	10.0	5000
Snug Harbor Anchorage	50	E	4000	200,000	10	80	100	2.0	4000
Wakefield Channel and Anchorage	50	E	5000	250,000	9	80	100	1.8	4500
	10	N	7000	70,000	9	0	100	9.0	6300
Wakefield Anchorage, additional 7 acres	80	E	3000	240,000	10	90	100	1.0	2400
	4	N	4000	16,000	10	0	100	10.0	1600
Total									\$44400

* 40 boats added gradually over 50-year project life; if added immediately total benefit would be \$12,800; this is equivalent to \$5,000 annually.

** Benefit is for elimination of loss of existing returns resulting from expected shoaling if not maintained.

Table D-8 summarizes the annual benefits of each feature of the plan for navigation improvement.

TABLE D-8

ANNUAL BENEFITS

NAVIGATION IMPROVEMENT (SINGLE PURPOSE)

POINT JUDITH AREA

<u>Description</u>	<u>Benefits</u>	
	<u>Commercial</u>	<u>Recreational</u>
Entrance Channel	\$22,300	-
Inner Harbor Anchorage add'l 6 acres	0	\$ 1,200
Little Comfort Anchorage	-	10,100
Channel to Little Comfort Anchorage	-	7,800
Snug Harbor Channel and Anchorage	-	10,500
Wakefield Channel and Anchorage	-	11,000
Wakefield Anchorage, add'l 7 acres	-	4,000
Totals:	\$22,300	\$44,600

Total Annual Benefit \$66,900

The recreational benefits are considered to be 50 percent general and 50 percent local in nature. Therefore the improvement would result in the general and local benefits in Table D-9.

TABLE D-9

RECREATIONAL BENEFITS

NAVIGATION IMPROVEMENT (SINGLE PURPOSE)

POINT JUDITH AREA

<u>Description</u>	<u>General</u>	<u>Local</u>	<u>Total</u>
Entrance Channel	\$22,300	0	\$22,300
All Other Features	22,300	22,300	44,600
Totals	\$44,600	\$22,300	\$66,900

D-21. COMPARISON OF BENEFITS TO COSTS

The plan of improvement described above with estimated annual benefits of \$66,900 and estimated annual charges of \$42,900, results in a benefit-cost ratio of 1.6 to 1.0 with each feature of the plan being justified separately.

D-22. PROPOSED LOCAL COOPERATION

The benefits to be derived from the deepening of the entrance channel are commercial navigation benefits and the cost will therefore be borne entirely by the Federal government. The benefits attributable to the remaining improvements are purely recreational in character. The apportionment of cost between the United States and local interests for these improvements, based on the percentage of local benefits applied to project first costs, requires that local interests make a cash contribution of 50 percent of the cost of construction of all the features other than the entrance channel. This local cash contribution is presently estimated at \$265,000.

Local interests would also be required to:

a. Provide without cost to the United States all lands, easements and rights-of-way required for construction and subsequent maintenance of the project and of aids to navigation upon request of the Chief of Engineers, including suitable areas determined by the Chief of Engineers to be required in the general public interest for initial and subsequent disposal of spoil and necessary retaining dikes, bulkheads and embankments therefore or the cost of such retaining works. Undeveloped areas are available near the harbor for spoil disposal.

b. Hold and save the United States free from damages that may result from the construction and maintenance of the project.

c. Provide and maintain without cost to the United States necessary mooring facilities and utilities including public landings with suitable supply facilities open to all on equal terms.

d. Provide two public landings open to all on equal terms, one at Snug Harbor, and one at Wakefield.

The additional cost of these requirements of local cooperation is estimated at \$20,000 each for the two public landings and \$20,000 spoil disposal areas for a total estimated cost of \$60,000.

D-23. APPORTIONMENT OF COSTS AMONG INTERESTS

Local interests should bear a portion of the cost of the proposed project

commensurate with the local benefits realized from the improvements. The apportionment of costs between the United States and local interests is made so that the Federal and non-Federal share of the project construction costs are in the same ratio as the evaluated general and local benefits. Of the initial construction cost of \$820,000 the Federal government would bear the entire cost of deepening the entrance channel (\$290,000). Of the remaining \$530,000 local interests would make a cash contribution of 50 percent (\$265,000). The Federal cost would be \$555,000 plus \$8,000 for preauthorization survey studies.

D-24. COORDINATION WITH OTHER AGENCIES

All Federal, State and local agencies having interest in the improvement of Point Judith Harbor and Pond were notified of the public hearings at Wakefield and Narragansett, Rhode Island on December 17, 1958, and June 6, 1960. Representatives of the U.S. Fish and Wildlife Service, the State of Rhode Island, the towns of Narragansett and South Kingstown, commercial fishing groups, sport fishermen and other local interests have all been consulted during the study concerning the effect of the proposed improvements on their activities.

The U.S. Fish and Wildlife Service was consulted on the effect of the improvements on fish and wildlife resources in the area. They reported that there would be no significant adverse effects upon the fish and wildlife resources as a result of the actual deepening and widening of existing channels, the provision of a channel and anchorage in the Potter Pond Channel and the enlarging of the anchorage at Wakefield, but that significant adverse effects could be involved in dredging operations that involve beach and sand dune fill material and spoil disposal areas associated with channel and anchorage improvements. The alternate channel route in the center of the Pond could have direct adverse effects on fish and wildlife resources by causing outright destruction of shellfish and permanent removal of productive shallow-water habitat with the substitution of less desirable deep water conditions. In view of these possibilities they recommend, (1) that dredging for channel and anchorage improvements and for fill material be limited to those sites which would be least damaging to the fish and wildlife resources of the area, and (2) that spoil disposal sites selected as a result of navigation and anchorage improvements be decided upon in cooperation with the Rhode Island Division of Fish and Game and the U.S. Fish and Wildlife Service.

The Bureau of Public Roads of the U.S. Department of Commerce reported that the improvements would have no effect on present or proposed highways in the area.

Local and State officials have approved the plan and indicated that the requirements of local cooperation would be met.

D-25. DISCUSSION

Point Judith Harbor and Pond are located on the south shore of Rhode Island about 40 miles south of Providence and about 2 miles west of Point Judith. Point Judith Harbor of Refuge is an artificial harbor formed by three Federal breakwaters and Point Judith Pond is a tidal lagoon connected to the Harbor of Refuge by a Federal channel 15 feet deep which extends to terminal facilities within the pond. The pond extends about 4 miles north to Wakefield and is about one mile wide.

The history of Federal studies in Point Judith Harbor and Pond dates back to 1873. The existing project was authorized by Congressional acts of 1890, 1907, 1910, 1919, and 1948. The improvement consists of the three Harbor of Refuge breakwaters, a 15-foot entrance channel with branches to the east and west sides of the pond, a 10-foot anchorage between these branch channels, a 6-foot channel up the pond to Wakefield and a 5-acre anchorage at the head of the pond.

At public hearings on December 17, 1958, and June 6, 1960, local interests requested improvements in the Federal navigation project to include repair of the breakwaters forming the Harbor of Refuge, deeper and wider channels, additional anchorage areas, and a bulkhead along the shore north of State Pier No. 4 in Jerusalem.

Commercial fishing in the area has increased extensively in past years, the value of the catch landed in 1959 being nearly \$1,700,000. Recreational boating in the area has expanded to the extent that there are about 2000 boats with an estimated total value of \$5,000,000 based in the Pond.

The plan of improvement that would best meet the present and reasonable prospective needs of navigation in the Pond is outlined below.

a. Deepen the existing entrance channel and the branch channel along the east side of the pond to Galilee to a depth of 20 feet at mean low water.

b. Enlarge the existing Inner Harbor Anchorage at Galilee to provide an additional 6 acres, 10 feet deep.

c. Provide an 8-acre anchorage, 8 feet deep, just south of Little Comfort Island.

d. Provide a 10-foot deep channel, 150 feet wide, along the State finger piers at Galilee, to Little Comfort Anchorage.

e. Provide a 5-acre anchorage 6 feet deep, and an access channel thereto 100 feet wide and 6 feet deep in Potter Pond Channel south of Snug Harbor.

f. Deepen the existing 100-foot wide channel to Wakefield and the existing Wakefield anchorage from 6 feet to 8 feet deep.

g. Enlarge the existing Wakefield anchorage to provide an additional 7 acres, eight feet deep.

These improvements would reduce hazards and congestion and attract an additional 74 pleasure boats and 35 fishing boats to the local fleet.

The first cost of improvements outlined above is estimated to be \$820,000. Local interests would be required to make a cash contribution equal to 50 percent of the \$530,000 cost of construction of recreational navigation improvements or \$265,000, but no contribution would be required toward the \$290,000 cost of deepening the entrance channel for commercial navigation. Therefore the local costs would be \$265,000 and the Federal cost \$555,000 for construction. Additional annual maintenance is estimated at \$11,300. The annual benefits accruing to the improvements amount to \$66,900 and the annual charges are \$42,900. This results in a benefit to cost ratio of 1.6 to 1.0.

The terms of local cooperation for the proposed improvement require that local interests make a cash contribution of \$265,000, hold the United States free from damages and provide all necessary lands, easements, rights of way and spoil disposal areas. Local officials have been consulted and have approved the plan and indicated that these requirements of local cooperation would be met.

The U.S. Fish and Wildlife Service has been consulted and they have reported that there would be no adverse effect on fish and wildlife resources as a result of actual deepening of existing channels and anchorages, from the provision of a channel and anchorage south of Snug Harbor, or enlarging the anchorage at Wakefield. However, they reported that significant adverse effects could result from dredging operations that involve beach fill and spoil disposal areas and recommend that spoil disposal sites be selected to minimize such damages.

D-26. ADDITIONAL NAVIGATION IMPROVEMENTS JUSTIFIED IN CONNECTION WITH HURRICANE PROTECTION WORKS.

During the course of the study it was found that additional

navigation improvements could be justified if dredged to obtain material for hurricane protection works. The following improvements or alternatives, which are not economically justified for construction on the basis of navigation benefits alone, would be justified if combined with hurricane protection improvements:

a. Relocate the entrance channel in a straight line to the Breachway with a depth of 20 feet as previously justified.

b. Provide an additional 5 acres, 10 feet deep at the Inner Harbor Anchorage totalling 11 additional acres.

c. Provide an additional two feet in depth in the Snug Harbor Channel and Anchorage.

The estimated first cost of the above items would be \$415,000, \$94,000 and \$60,000 respectively, if they were constructed for navigation purposes only. The difference in cost of the 20-foot entrance channel in its present location and in the alternate location is \$125,000. This represents an increase in annual costs of \$4500; the increased maintenance in the new location would be \$1800 annually resulting in a total increase in annual charges of \$6300. The only substantial additional benefit accruing to the relocated channel would be a result of time saved by the Block Island ferry. At present it is estimated that the extreme caution required in negotiating the entrance channel results in a time loss of a quarter of an hour on each round trip. The ferry makes an average of 485 round trips per year with a total delay of about 120 hours. With operating costs being estimated at about \$25 per hour this results in a total loss of about \$3000 annually. This additional benefit cannot justify relocation of the entrance channel in itself but if it were done as a part of hurricane protection measures the additional annual benefit of \$3000 would justify the additional annual maintenance of \$1800.

The first cost of an additional 5 acres of 10-foot Inner Harbor anchorage would be about \$94,000 with annual costs being \$3700 and annual maintenance being \$800 for a total annual charge of \$4500. The additional anchorage area would attract additional transient boats during the summer months, especially during the Atlantic Tuna Tournament and during fleet visits. It is considered that this summer use by transients would be approximately equivalent to six new boats added to the local fleet, based on 8 large transient boats per acre, or 40 boats for one-sixth of a year. These six boats with an average depreciated value of \$5000 each or a total value of \$30,000 and an estimated return of 8% and a 100% gain results in an annual benefit of \$2400. The resulting benefit-cost ratio is 0.5, therefore the improvement is not justified. The annual benefit of \$2400 would justify the additional annual maintenance of \$800

if the area were dredged to obtain fill for the hurricane protection project.

The first cost of providing an 8-foot channel and anchorage at Snug Harbor would be \$260,000 as compared to \$200,000 for a 6-foot channel and anchorage or an increase of \$60,000. The additional annual cost would be \$2400 and the additional maintenance \$300 resulting in increased annual charges of \$2700.

The deeper channel and anchorage would attract larger, deeper-draft boats. The estimated 10 new boats to be purchased as a result of the 6-foot improvement would therefore be of greater value, conservatively estimated at \$1000 per boat; resulting in a total increase in value of \$10,000. Based on an ideal return of 10 percent to be realized as a result of the improvement, the additional annual benefit would be \$1000. The benefit to cost ratio for the additional depth is 0.4 and the improvement is therefore not justified. However, the annual benefit of \$1000 would justify the additional maintenance of \$300 if the extra depth were constructed to obtain fill for the hurricane protection project.

The combined plan for navigation hurricane flood protection and beach erosion control is shown on Plate D-5.

D-27. RECOMMENDATION

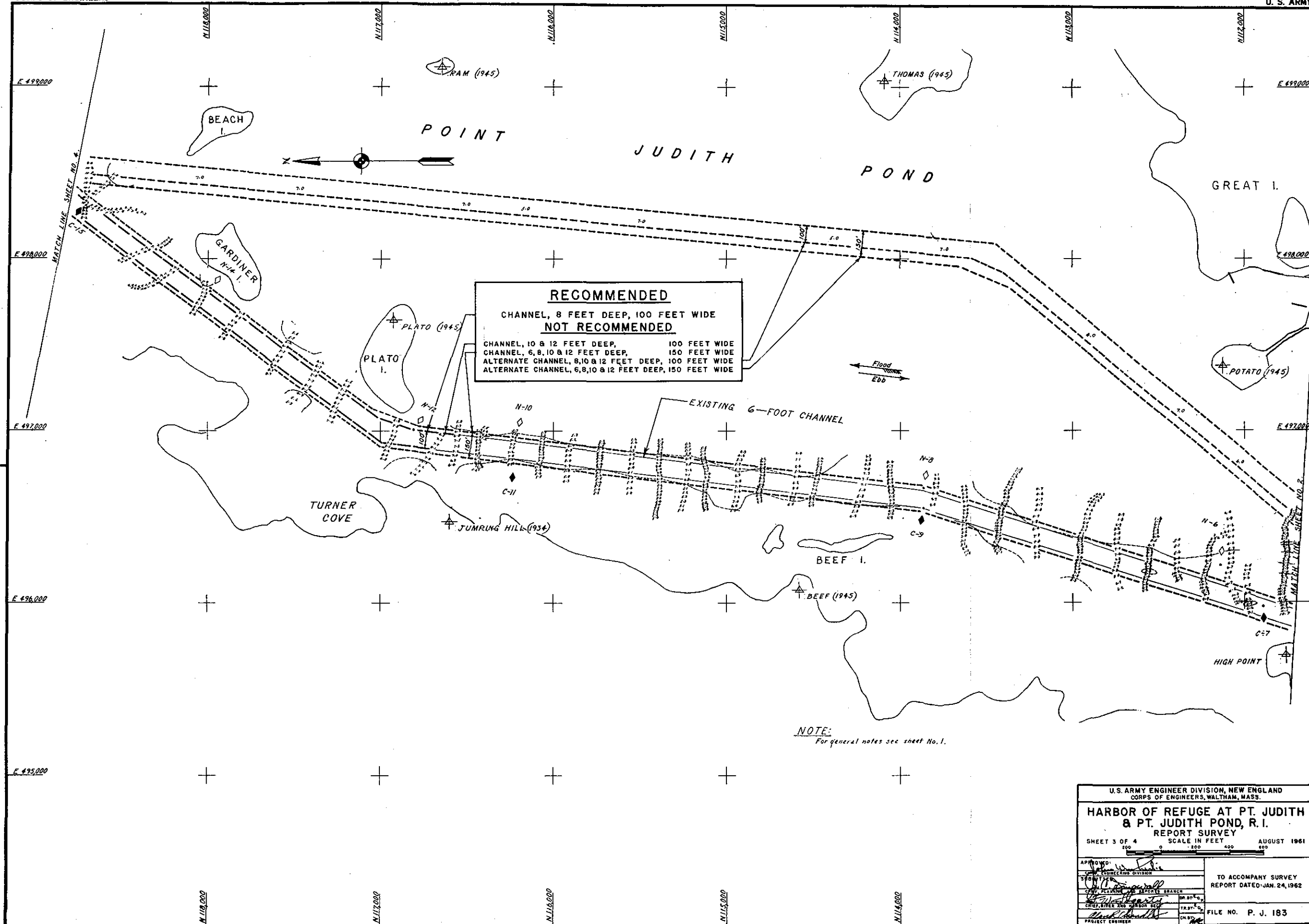
In view of the foregoing, the Division Engineer recommends that the existing project for Point Judith Harbor and Pond, Rhode Island be modified to provide for (1) deepening the existing entrance channel and east branch thereof to a depth of 20 feet, (2) enlarging the existing 10-foot Inner Harbor anchorage from 5 to 11 acres, (3) dredging an 8-acre anchorage, 8 feet deep, south of Little Comfort Island, (4) dredging a 10-foot channel, 150 feet wide, along the finger piers at Galilee to the Little Comfort Anchorage, (5) dredging a 5-acre anchorage, 6 feet deep, and a 6-foot access channel, 100 feet wide, south of Snug Harbor, (6) deepening the existing 6-foot channel to Wakefield and the existing Wakefield anchorage to 8 feet, and (7) enlarging the anchorage at Wakefield to include an additional 7 acres, 8 feet deep. The Federal cost of these improvements is \$555,000 for construction, \$8,000 for preauthorization studies, and \$11,300 annually for maintenance. Any of the above separately justified items may be constructed independently whenever the necessary funds are provided and applicable local requirements are met. This recommendation is made subject to the condition that local interests (1) hold and save the United States free from damages due to construction of the improvements, (2) provide without cost to the United States all lands, easements, rights-of-way and spoil disposal areas for the new work and subsequent maintenance, (3) provide public landings at Snug Harbor and Wakefield open to all on equal terms, and (4)

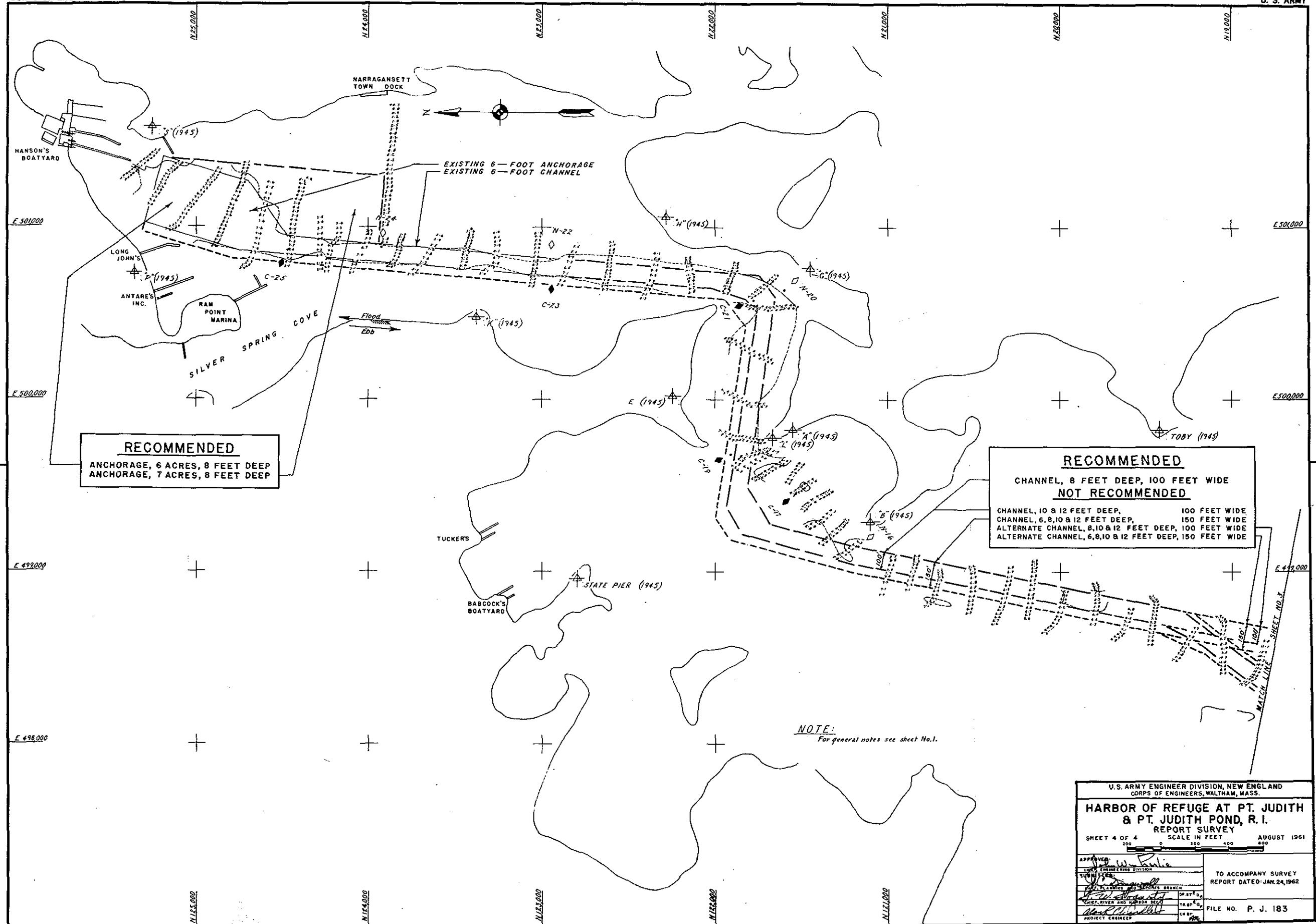
contribute in cash an amount presently estimated at \$265,000. The navigation improvement described above is economically justified in all its parts and has an overall benefit to cost ratio of 1.6 to 1.0.

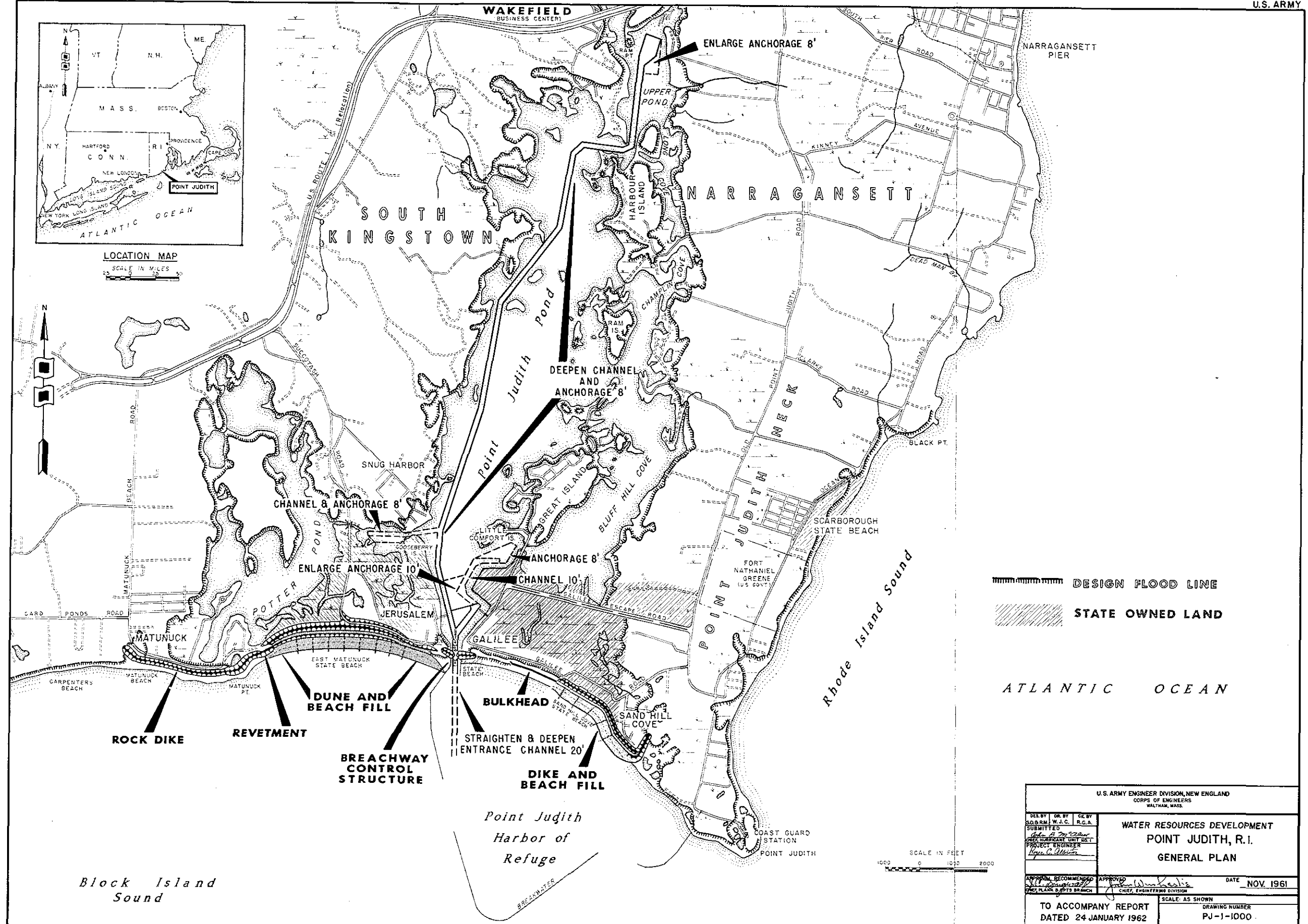
The Division Engineer further recommends that if hurricane and beach protection improvements are made concurrently with the navigation improvements that (1) the entrance channel be straightened to a depth of 20 feet, in lieu of (1) above, (2) an additional 5 acres of anchorage at 10 feet be provided at Inner Harbor Anchorage, to total 16 acres, and (3) an additional 2 feet of depth be provided in Snug Harbor Channel and Anchorage, to total 8 feet. The Division Engineer also recommends future maintenance for the foregoing additional improvements.











APPENDIX E

BEACH EROSION CONTROL IMPROVEMENTS
DESIGN STUDIES AND COST ESTIMATES

APPENDIX E

APPENDIX E
BEACH EROSION CONTROL
TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
E-1	General	E-1
E-2	Prior Reports	E-1
	a. Beach erosion control project at Sand Hill Cove State Beach	
	b. Authorized beach erosion control project at East Matunuck State Beach	
E-3	Statement of the Beach Erosion Problems	E-3
E-4	Analysis of the Erosion Problems	E-4
	a. Shore processes	
	b. Methods of correcting conditions	
	c. Design criteria for beach erosion control	
E-5	Plan of Improvement	E-6
E-6	Economic Data on Authorized Project at East Matunuck State Beach	E-7
	a. First cost	
	b. Annual charges	
	c. Annual benefits	
	d. Justification	
E-7	Interrelated Effects of Hurricane Protection and Beach Erosion Control Projects	E-10

TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
E-1	Estimated First Costs, Beach Erosion Control Project, East Matunuck State Beach	E-8
E-2	Annual Charges, Beach Erosion Control Project, East Matunuck State Beach	E-9
E-3	Annual Benefits, Beach Erosion Control Project, East Matunuck State Beach	E-9

PLATES

E-1	Plan of Improvements, Beach Erosion Control, East Matunuck State Beach
E-2 & E-3	Water Resources Development, Point Judith, Plan and Sections

APPENDIX E

BEACH EROSION CONTROL

E-1. GENERAL

This appendix describes and analyzes the beach erosion problems in the area between Point Judith and Matunuck, discusses the completed project at Sand Hill Cove State Beach and the authorized project at East Matunuck State Beach. It also summarizes data from the authorizing document on East Matunuck State Beach and includes information on the inter-related effects of the beach erosion control and the hurricane protection projects.

E-2. PRIOR REPORTS

A cooperative beach erosion control study on the south shore of Rhode Island, completed in 1949 by the Corps of Engineers, is the basis of the existing project at Sand Hill Cove State Beach. The report thereon was printed in House Document No. 490, 81st Congress, 2nd Session. No Federal project was recommended for East Matunuck Beach, then under private ownership, but it was concluded that artificial placement of sand fill, a groin system and construction of a sand dune or other barrier to landward sand movement of beach material could be used to improve the beach east of Matunuck Point, and that rock revetment would prevent further erosion of the headland.

A second cooperative beach erosion control study which included East Matunuck State Beach, completed in 1958 by the Corps of Engineers and described in House Document No. 30, 86th Congress, 1st Session, is the basis for an authorized project to provide for sand fill and a system of groins.

a. Beach erosion control project at Sand Hill Cove. The existing beach erosion control project at Sand Hill Cove State Beach was authorized by the River and Harbor Act of September 3, 1954. This provides for Federal participation in the amount of one-third the first cost of construction of improvements to the publicly owned shore. The authorization provided for widening the beach for a length of about one mile west from the east limit of the State beach an average of about 65 feet by direct placement of sand, construction of a barrier to landward sand movement, and if necessary, the construction of 10 impermeable groins.

The State of Rhode Island constructed the portion of the improvement on public lands and furnished assurances that the required conditions of local cooperation would be met. These conditions require that the State of Rhode Island or responsible local authorities

- (1) Adopt the aforementioned plan of protection and improvement;
- (2) Submit for approval by the Chief of Engineers detailed plans and specifications and arrangements for prosecuting work on the project prior to the commencement of such work;
- (3) Provide at their own expense all necessary lands, easements and rights-of-way for accomplishment of their work; and
- (4) Give satisfactory assurances that they will
 - (a) Maintain the protective and improvement measures during the useful life thereof as may be required to serve their intended purpose;
 - (b) Hold and save the United States free from all claims for damages that may arise before, during, or after the prosecution of the work;
 - (c) Assure that water pollution that would endanger the health of the bathers will not be permitted; and
 - (d) Maintain continued public ownership of the beach and its administration for public use only.

The total costs for all requirements of local cooperation under terms of the project authorization including required non-Federal contributions amounted to \$80,286, the Federal share being \$40,143 for a total cost of \$120,429.

b. Authorized beach erosion control project at East Matunuck State Beach. The beach erosion control project at East Matunuck State Beach was authorized by the River and Harbor Act of July 14, 1960. It provides for Federal participation in the amount of one-third the first cost of construction consisting of widening about 3830 feet of beach generally to a 150 foot width by direct placement of sand, construction of eight stone groins and installation of sand fences, the construction of the groins

to be deferred pending demonstration of need except the most easterly groin and that near the middle of the shore frontage.

The estimated first cost of the project is \$288,000 with the Federal share being \$96,000.

Federal participation was authorized subject to the conditions that local authorities

- (1) Obtain approval by the Chief of Engineers prior to commencement of work, of detailed plans and specifications and arrangements for prosecution of the work;
- (2) Provide suitable appurtenant facilities to the extent necessary for realization of evaluated benefits;
- (3) Provide at their own expense all necessary lands, easements and rights-of-way;
- (4) Assure that water pollution that would endanger the health of the bathers will not be permitted;
- (5) Assure maintenance and periodic nourishment of the protective and improvement structures during their useful life as may be required to serve their intended purpose; and
- (6) Maintain continued public ownership of the shores and their administration for public use during the economic life of the project.

No work has been done on construction of the authorized Federal project.

E-3. STATEMENT OF THE BEACH EROSION PROBLEMS

The principal erosion problems in the area between Point Judith and Matunuck are located at East Matunuck State Beach and the headland immediately to the west.

The area between Point Judith and the Breachway is protected from normal storm waves by the breakwaters forming the Harbor of Refuge. The easterly portion is protected by groins of the existing beach erosion control project at Sand Hill Cove State Beach. The westerly portion has remained fairly stable in recent years with some accretion at the Breachway jetty.

For a short distance west of the Breachway accretion has also occurred. Immediately to the west of this accretion area at East Matunuck State Beach, the barrier beach has been leveled by storm driven water and waves and is now frequently overtopped by winter storms leaving deposits of sand and debris in Potter Pond and on Succotash Road. Continuation of this could result in breaching in the vicinity of Potter Pond. In addition to the flattening of the dunes, there has been severe and continuing recession of the shoreline at East Matunuck State Beach, particularly at the westerly end, and a general steepening of the beach below mean low water creating dangerous bathing conditions. This area is the subject of the authorized project mentioned in the preceding paragraph.

The headland to the west has eroded to the extent that several properties have been completely destroyed and others are now being threatened as the road there is being undercut by frontal attack of storm waves.

West of Matunuck Point at Matunuck Beach the shore line and offshore depth changes indicate that the beaches in this area have been relatively stable during the period of record. In view of the satisfactory condition of these beaches, no beach erosion control measures are needed in the immediate future.

E-4. ANALYSIS OF THE EROSION PROBLEMS

a. Shore processes. The supply of new material to the beaches in the area has been reduced as glacial till headlands are protected by structures or by boulders and cobbles remaining from former erosion. Present supply comes largely from erosion of adjacent beaches. In prior reports (see par. E-2) it was concluded that the breakwaters at Point Judith sheltered the area from southeasterly waves and that the accretion west of the west breakwater indicated a predominantly eastward littoral drift in the area west of the Breachway. Available evidence supports this conclusion. Apparently lack of a sufficient supply of material from the west results in erosion of the beaches by waves approaching from that direction.

During the 10-year period from 1946 to 1956, the average annual losses or deficiency in supply in the East Matunuck area amounted to about 40,000 cubic yards, of which about 32,000 occurred within the State-owned shore. Significant volumes of sand have been moved landward across the barrier beaches into the marshes and ponds during hurricanes.

b. Methods of correcting conditions. At East Matunuck State Beach the erosion problem results from insufficient material entering the area to replace losses. The problem may be overcome by artificially providing material to replace the losses. This may be accomplished either by stockpiling suitable sand for natural distribution or by direct placement along the beach. The direct placement method is preferred at East Matunuck State Beach, and the use of groins to retain the sand fill is required since erosion losses there are substantial. Sand fences would be used to reduce loss of beach materials by wind forces.

The headland directly to the west would be revetted as a part of hurricane protective measures in the area and would be tied into the authorized beach erosion control project for East Matunuck State Beach.

c. Design criteria for beach erosion control. Proposed beach protective measures are designed to provide protection against ordinary storms of comparatively frequent occurrence (at least once a year). They are not intended to provide protection to waterfront structures in the event of a hurricane or exceptional storm of infrequent occurrence, although even under these conditions some protection will be afforded. Specific design criteria used for protective works are as follows:

(1) Design tide. The design tide is the maximum elevation which occurs at least once a year. Tide records indicate that stages in excess of 2.5 feet above mean high water occur about once each year at Newport, Rhode Island.

(2) Groins. The horizontal shore section of the groin should ordinarily have a top elevation not lower than the general height of berms of existing beaches and a length equal to the berm width of the anticipated beach. At East Matunuck State Beach the top elevation should be approximately 5 feet above mean high water. Barrier groins which are intended to completely block passage of littoral drift or reduce it considerably should be higher than the anticipated beach berm. Also, in the case of stone groins, it is desirable to have the top elevation about one foot higher because of the spaces between cover stones. The intermediate sloped section should not be steeper than the slope of the existing fore-shore, and should approximately equal the anticipated beach slope. The top elevation of the outer section should generally not be lower than one foot above mean low water. For stone construction, the minimum height of groins should be three feet. Groins should be sandtight and firmly anchored at their shore ends to prevent flanking. Groin lengths are generally determined by the shape of the fillet and required width at the up-drift end of the space between groins. Stone sizes and side slopes for

groins are computed using the WES formula and the design wave. The design wave used is the maximum wave that can approach without breaking, in the depth of water at the groin if the fetch is not a limiting factor. Throughout the study area, such waves can be generated with the available fetch. Blankets of spalls or crushed stone are used under stone groins to minimize settlement due to scour.

(3) Sand fills. Berm elevations of proposed fills are based on widths found to afford protection in the area. Computed volumes of fills are based on slopes similar to existing slopes, but fills can be placed initially to a steeper slope and permitted to take a natural slope under wave action. Based on these criteria berm elevations are approximately five feet above mean high water, and beach widths above mean high water are approximately 150 feet with slopes of 1 on 15 to 1 on 20. Suitable sand for beach fills would have size and gradation characteristics similar to those of the sand components of the existing material on the beaches. The annual replenishment quantity is estimated to be about 32,000 cubic yards at East Matunuck State Beach if no retaining structures are provided. It is estimated that the use of groins there would reduce losses by at least 25 percent, resulting in an annual replenishment quantity of about 24,000 cubic yards. For the purpose of detailed design of beach fills, the investigations of materials on the beaches and in proposed borrow areas must be supplemented when plans and specifications are being prepared.

E-5. PLAN OF IMPROVEMENT

The basic plan for restoration and stabilization of East Matunuck State Beach follows the authorized project and comprises direct placement of suitable sand along the shore to form a beach generally 150 feet wide at mean high water fronting on Succotash Road and the low dunes west thereof, sand fences to promote dune formation and a system of eight groins to reduce losses of beach material, six of these groins being deferred construction. Stabilization of the beach would be effected by periodic nourishment. Dredging experience indicates that suitable sand for initial fill and subsequent nourishment may be obtained from Point Judith Pond within practical distance for placement by pipeline dredge. Additional information on the authorized project for East Matunuck State Beach is contained in paragraph E-2b and in House Document No. 30, 86th Congress, 1st Session.

In addition, revetment of the headland at Matunuck Point as part of the hurricane protection plan, would augment the beach erosion control measures since it would halt the severe land loss occurring there. The entire shoreline of the headland would be revetted to an elevation of 20

feet above mean sea level with a 1 on 5 slope. The rock would extend around the easterly end of the point and tie in under the proposed beach fill and dune restoration at East Matunuck State Beach.

E-6. ECONOMIC DATA ON AUTHORIZED PROJECT AT EAST MATUNUCK STATE BEACH

a. First cost. The estimated first cost of the authorized beach erosion control project at East Matunuck State Beach is \$288,000 with the Federal share being \$96,000.

In addition to restoring adequate protective and recreational beaches, local interests would provide at their own expense bathhouses, parking areas, and similar appurtenant items to facilitate recreational use. Such facilities are required for realization of evaluated recreational benefits from the beach developments. Based on costs of similar facilities at other public beaches, it is estimated that the State and Town will expend about \$250,000 in addition to their shares of the costs of beach restoration. These costs are not included in the first cost when determining economic justification of the proposed plan. The estimate of first costs for the authorized project is outlined in Table E-1.

b. Annual charges. Interest and amortization charges have been computed using an interest rate of 2-5/8 percent on Federal funds and 3-1/2 percent on non-Federal funds. A useful project life of 50 years has been assumed in determining amortization charges. These annual charges do not include interest and amortization on the first cost of the beach facilities nor the maintenance and operation of the facilities since they are considered to be self-liquidating, that is, fees charged for parking and bathhouse use will cover these charges. Estimated annual charges are given in Table E-2.

TABLE E-1
ESTIMATED FIRST COSTS
(1961 Price Level)
BEACH EROSION CONTROL PROJECT
EAST MATUNUCK STATE BEACH

<u>Item</u>	<u>Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>BEACH</u>				
Sand fill	90,000	c.y.	\$ 1.38	\$124,000
Rock fill, groins	8,930	c.y.	10.70	96,000
Sand fence	7,700	l.f.	0.93	<u>7,000</u>
				\$227,000
Contingencies				<u>33,000</u>
TOTAL COST - BEACH				\$260,000
<u>ENGINEERING AND DESIGN</u>				8,000
<u>SUPERVISION AND ADMINISTRATION</u>				<u>20,000</u>
SUBTOTAL - FIRST COST				\$288,000 (1)
Preauthorization Survey Studies				\$ 6,000
Estimated First Cost to the United States				\$ 96,000
Estimated First Cost to Local Interests				\$192,000 (1)

(1) Does not include first cost of \$250,000 for construction of beach facilities by local interests as a part of the requirements of local co-operation.

TABLE E-2

ANNUAL CHARGES

BEACH EROSION CONTROL PROJECT

EAST MATUNUCK STATE BEACH

<u>Item</u>	<u>Annual Cost</u>
Interest	\$ 9,400
Amortization	2,500
Maintenance	1,200
Periodic Nourishment	<u>34,000</u>
TOTAL ANNUAL CHARGES	\$47,100

c. Annual benefits. The estimated benefits include direct damages prevented and recreational benefits. It is considered that development of appurtenant facilities must be accomplished in order that the estimated recreational benefits will result. Peak day beach attendance of 18,000 has been estimated for East Matunuck State Beach. Total attendance is computed from attendance distribution curves developed from daily attendance records at Rocky Neck State Beach in East Lyme, Connecticut. A list of evaluated annual benefits is given in Table E-3 below.

TABLE E-3

ANNUAL BENEFITS

BEACH EROSION CONTROL PROJECT

EAST MATUNUCK STATE BEACH

<u>Item</u>	<u>Annual benefit</u>
Direct damages prevented	\$ 3,900
Recreational benefits	<u>214,800</u>
TOTAL ANNUAL BENEFITS	\$218,700

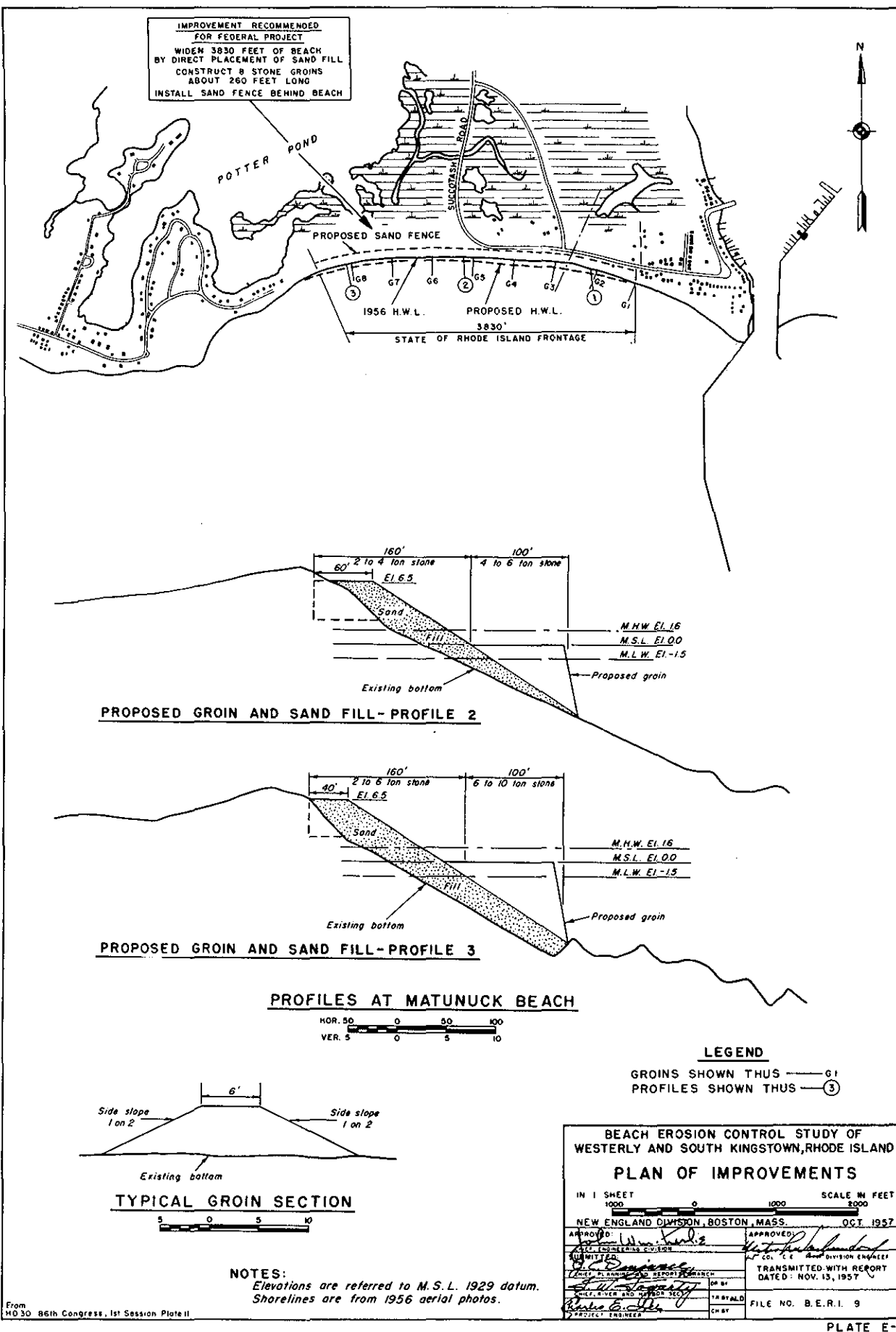
d. Justification. The estimated annual benefits are \$218,700 at East Matunuck State Beach and the estimated annual costs are \$47,100 resulting in a benefit to cost ratio of 4.6 to 1.0. The costs of other beach protection measures constructed primarily as hurricane protection will be included in the cost of the hurricane protection project.

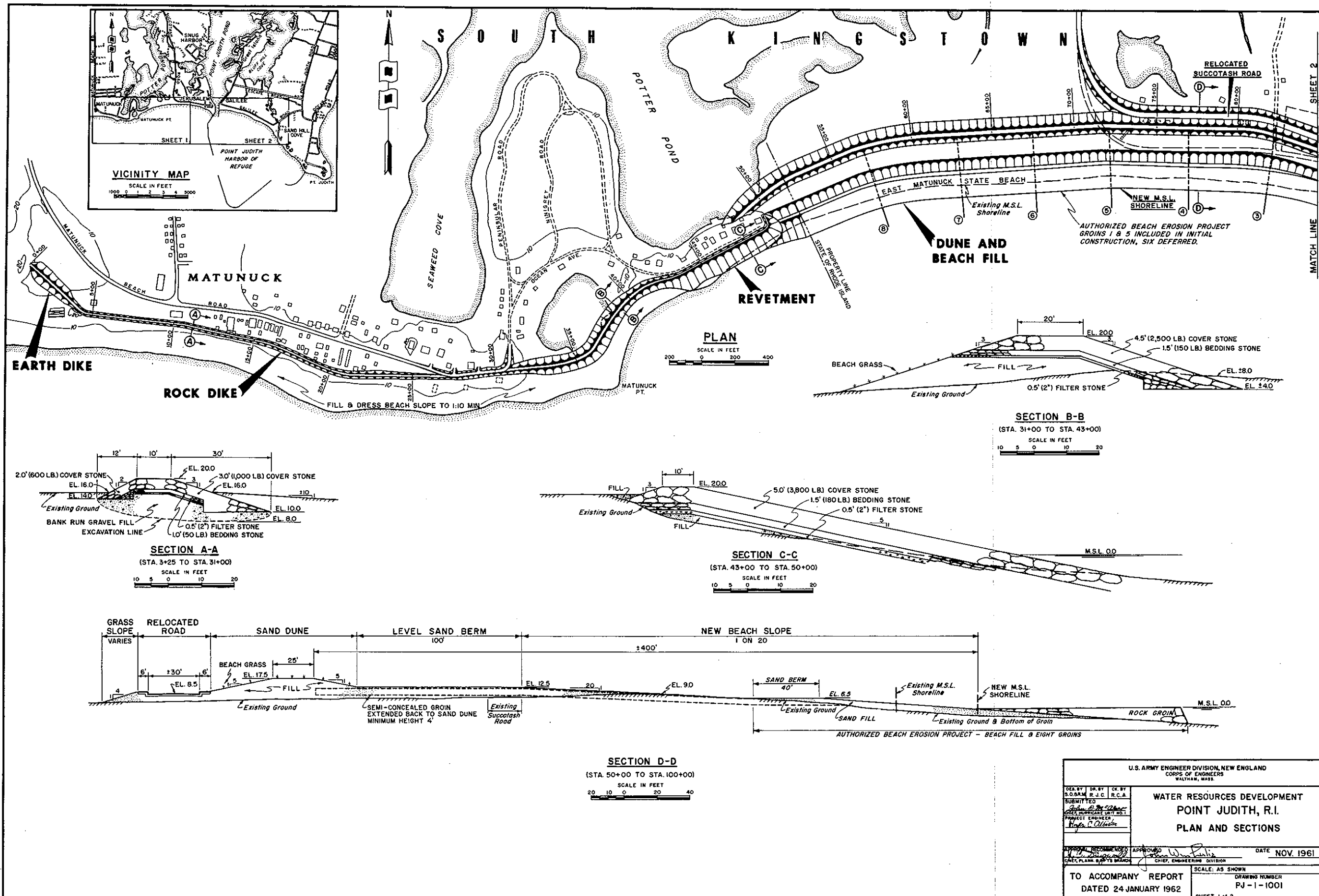
E-7. INTERRELATED EFFECTS OF HURRICANE PROTECTION AND BEACH EROSION CONTROL PROJECTS

The existing beach erosion control projects at Sand Hill Cove State Beach and East Matunuck State Beach would be included in the overall plan of water resources development in conjunction with hurricane protection. These beach erosion control projects provide the first line of defense against tidal flooding. The authorized project at East Matunuck State Beach could be completed prior to or concurrently with the hurricane protection features of a multi-purpose plan. Both beach erosion projects would be maintained as a part of the overall plan to ensure that there will always be adequate beach width in front of the flood control dunes and dikes.

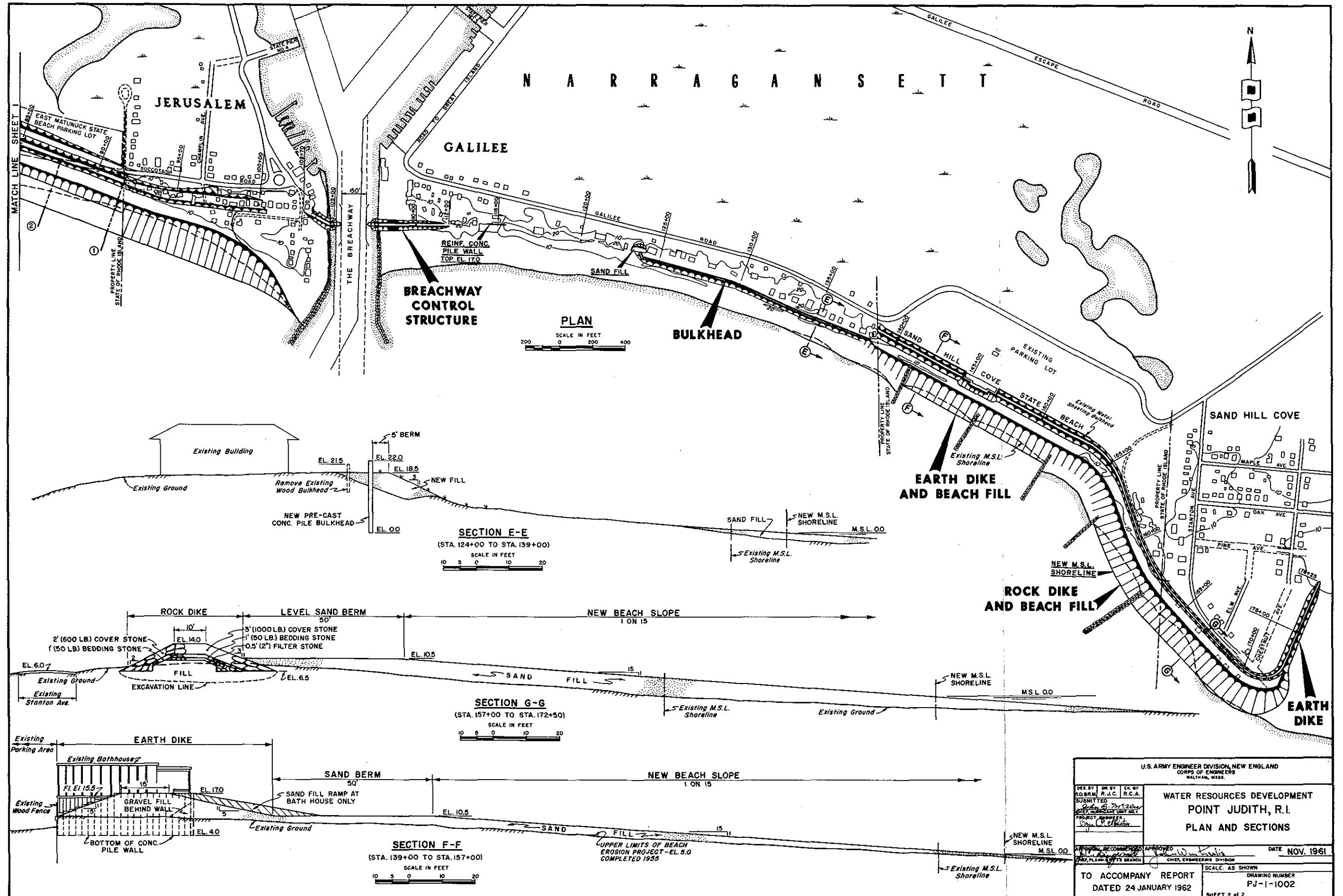
The restored dunes and protective dikes of the hurricane protection plan would aid in retaining the beach erosion control projects by preventing overtopping and breaching of the barrier beaches which now results in large quantities of sand moving from the beaches into the tidal ponds and marshes.

The revetment at Matunuck Point and the rock-faced dikes, although part of the hurricane protection feature, would provide invaluable beach protection functions by preventing land loss and overtopping.





U.S. ARMY ENGINEER DIVISION, NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.			
DES. BY S.O.B.M.	DR. BY R.J.C.	CK. BY R.C.A.	WATER RESOURCES DEVELOPMENT POINT JUDITH, R.I. PLAN AND SECTIONS
SUBMITTED 24 JAN 1962			
CHECKED BY R.C.A.			
PROJECT ENGINEER R.C.A.			
APPROVED [Signature]			DATE NOV. 1961
TO ACCOMPANY REPORT DATED 24 JANUARY 1962			SCALE: AS SHOWN DRAWING NUMBER PJ-1-1001 SHEET 1 of 2



APPENDIX F

ALLOCATION AND APPORTIONMENT OF COSTS

APPENDIX F

APPENDIX F

ALLOCATION AND APPORTIONMENT OF COSTS

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
F-1	INTRODUCTION	F-1
F-2	ALLOCATION OF COSTS	F-3
F-3	APPORTIONMENT OF COSTS	F-4

TABLES

<u>Number</u>	<u>Title</u>	<u>Page</u>
F-1	Cost Allocation between Hurricane Protection, Beach Protection, Commercial Navigation and Recreational Navigation, excluding Wakefield Channel and Anchorage and Cost Apportionment between Federal and non-Federal Interests	F-6
F-2	Estimated First Costs - Alternative Beach Protection Project	F-8
F-3	Estimated Annual Costs - Alternative Beach Protection Project	F-9
F-4	Estimated First Costs - Alternative Hurricane Protection Project including Beach Protection	F-10
F-5	Estimated Annual Costs - Alternative Hurricane Protection Project including Beach Protection	F-12
F-6	Estimated First Costs - Alternative Commercial Navigation Project	F-13
F-7	Estimated Annual Costs - Alternative Commercial Navigation Project	F-13
F-8	Estimated First Costs - Alternative Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-14

TABLES (Cont'd)

<u>Number</u>	<u>Title</u>	<u>Page</u>
F-9	Estimated Annual Costs -Alternative Recreational Navigation Project, excluding Wakefield Channel and Anchorage	F-15
F-10	Estimated First Costs - Beach Protection and Commercial Navigation Project.	F-16
F-11	Estimated Annual Costs - Beach Protection and Commercial Navigation Project	F-17
F-12	Estimated First Costs - Beach Protection and Recreational Navigation Project, excluding Wakefield Channel and Anchorage	F-18
F-13	Estimated Annual Costs -Beach Protection and Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-19
F-14	Estimated First Costs - Commercial Navigation and Recreational Navigation Project, excluding Wakefield Channel and Anchorage	F-20
F-15	Estimated Annual Costs - Commercial Navigation and Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-21
F-16	Estimated First Costs - Hurricane Protection, Beach Protection and Commercial Navigation Project	F-22
F-17	Estimated Annual Costs - Hurricane Protection, Beach Protection and Commercial Navigation Project	F-23
F-18	Estimated First Costs - Hurricane Protection, Beach Protection and Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-24

TABLES (Cont'd)

<u>Number</u>	<u>Title</u>	<u>Page</u>
F-19	Estimated Annual Costs - Hurricane Protection Beach Protection and Recreational Navigation Project, excluding Wakefield Channel and Anchorage	F-26
F-20	Estimated First Costs - Beach Protection, Commercial Navigation and Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-27
F-21	Estimated Annual Costs - Beach Protection, Commercial Navigation and Recreational Navigation Project, excluding Wakefield Channel and Anchorage.	F-28
F-22	Estimated First Costs - Water Resources Development Plan, excluding Wakefield Channel and Anchorage.	F-29
F-23	Estimated Annual Costs - Water Resources Development Plan, excluding Wakefield Channel and Anchorage	F-31
F-24	Cost Allocation between Hurricane Protection and Beach Protection and Cost Apportionment between Federal and non-Federal Interests	F-32
F-25	Cost Allocation between Beach Protection and Commercial Navigation and Cost Apportionment between Federal and non-Federal Interests	F-33
F-26	Cost Allocation between Beach Protection and Recreational Navigation, excluding Wakefield Channel and Anchorage and Cost Apportionment between Federal and non-Federal Interests.	F-34
F-27	Cost Allocation between Hurricane Protection, Beach Protection and Commercial Navigation and Cost Apportionment between Federal and non-Federal Interests.	F-35
F-28	Cost Allocation between Hurricane Protection, Beach Protection and Recreational Navigation, excluding Wakefield Channel and Anchorage and Cost Apportionment between Federal and non-Federal Interests.	F-37

TABLES (Cont'd)

<u>Number</u>	<u>Title</u>	<u>Page</u>
F-29	Cost Allocation between Beach Protection, Commercial Navigation and Recreational Navigation, excluding Wakefield Channel and Anchorage and Cost Apportionment between Federal and non-Federal Interests.	F-39

APPENDIX F

ALLOCATION AND APPORTIONMENT OF COSTS

INTRODUCTION

F-1. The water resources development plan is composed of two elements. The first element of the plan consists of deepening to 8-foot mean low water, the Wakefield Channel and Anchorage, and enlarging the Wakefield Anchorage. Due to the distance of the Wakefield Channel and Wakefield Anchorage from the proposed hurricane protection and beach erosion control it would not be economical to transport the dredged material for use on the barrier beaches. For this first element of the plan, single purpose recreational navigation, the cost sharing was based on local interests making a cash contribution of 50 per cent of the first cost based on present policy for small boat harbors. No cost allocation was necessary. Tables C-5 and C-6, Appendix C, give the details of the first costs and annual costs, respectively, of this element of the plan.

The second element of the plan consists of the entire hurricane protection, beach protection, commercial navigation, and recreational navigation features, with the exception of the Wakefield Channel and Anchorage. For the second element of the plan, an allocation of costs for each project purpose and an apportionment of these costs between Federal and local interests was necessary; and this appendix explains the method used.

The annual costs of the water resources development plan, excluding the Wakefield Channel and Anchorage, were allocated by the separable costs-remaining benefits method to obtain the cost chargeable to each function. The cost of the Wakefield Channel and Anchorage was then added to obtain the total water resources development plan cost. The resulting distribution of costs for the total water resources development plan is summarized in the following table.

COST ALLOCATION AND COST APPORTIONMENT SUMMARY

	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Recreational Navigation</u>	<u>Total</u>
<u>COST ALLOCATION - ANNUAL COSTS</u>					
Amount	\$ 154,400	\$ 22,600	\$ 11,400	\$ 31,000	\$ 219,400
Percent of Total	71	10	5	14	100

<u>COST ALLOCATION AND COST APPORTIONMENT - FIRST COST</u>					
Federal Cost	1,905,100	39,200	212,800	256,500	2,413,600
Non-Fed. Cost	816,500	78,500	0	256,400	1,151,400
Total Cost	2,721,600	117,700	212,800	512,900	3,565,000
Percent of Total	76	3	6	15	100

The overall distribution of first costs for the total plan is Federal 68 percent, and non-Federal 32 percent. It may be noted that substantial savings in costs are obtained for each function by the combination in one multiple-purpose plan. More than 20 percent of the overall cost of separate projects is saved by this combination. Also, savings in operation and maintenance would accrue to both Federal and non-Federal interests as a result of the combination.

ALLOCATION OF COSTS

F-2. The allocation of costs for the multiple-purpose plan, excluding Wakefield Channel and Anchorage, by the separable costs-remaining benefits method is given in Table F-1. Based on annual costs and benefits, the method consists essentially of three steps:

a. Assigning to each of the four purposes of the multiple-purpose project the added cost of including that purpose in the combined project. The added cost for each purpose is referred to as its "separable cost."

b. Distributing the remaining "joint cost" of the multiple-purpose project between the four purposes in proportion to the "remaining benefits." The "joint cost" is the difference between the combined project cost and the sum of the four separable costs. The "remaining benefits" for each purpose is the difference between the total benefits for that purpose or the alternative single purpose project cost, whichever is less, and the "separable costs" for that purpose.

c. Adding the separable and joint costs to obtain the total allocated cost for each purpose.

The alternative hurricane protection project, as used in the allocation, includes all of the features of the alternative beach protection project (not including the completed Sand Hill Cove State Beach project). The total benefits, under the heading hurricane protection, are: \$450,500, comprises of \$231,800, hurricane protection benefits, and \$218,700 beach protection benefits. However, the amount of benefits actually used for the allocation is \$231,800. This was necessary in order to avoid a duplication of beach protection benefits.

The allocation of the average annual maintenance, operation and allowance for major replacements costs is shown in Table F-1. The details of the navigation maintenance, a Federal responsibility, are given in Table C-4, Appendix C.

Since the most economical alternative hurricane protection project includes all of the beach protection features and benefits of the two-purpose plan, a supplementary cost allocation, as indicated in Table F-24, was necessary. Since all hurricane protection, beach protection, annual maintenance, operation and allowance for major replacements costs is the responsibility of the local interests, the division of costs between the two purposes is not subject to any legal requirements. The total savings of maintenance, operation and allowance for major replacements costs in the two-purpose project, as compared with the sum of the two single-purpose alternative projects were, distributed in the same ratio as the savings in alternative project costs. The net maintenance, operation and allowance for major replacements costs was obtained by subtracting this savings from the single purpose alternative project maintenance, operation and allowance for major replacements costs. This same division of maintenance, operation and allowance for major replacements costs between the hurricane protection and beach protection purposes was used in all other cost allocations for this project.

The application of the separable costs-remaining benefits method of cost allocation to a four-purpose project, such as the Point Judith multiple-purpose plan, required the determination of the costs of all combinations of two and three-purpose projects. Supplemental cost allocations were necessary to determine the most of these costs. Supplemental cost allocations for two-purpose projects are given in Tables F-24, F-25 and F-26, and for three-purpose projects are given in Tables F-27, F-28 and F-29.

APPORTIONMENT OF COSTS

F-3. The apportionment of the total cost of the multiple-purpose plan between Federal and non-Federal interests is given in Table F-1. The first costs allocated to hurricane protection, including the costs of lands, easements and rights-of-way, but excluding the cost of preauthorization survey studies and aids to navigation, were apportioned 30 percent to non-Federal interests, and 70 percent to the Federal government following present policy. The Federal contribution to the cost of protecting the shores of publicly owned property was set at one-third of the project cost with the remainder paid for by local interests, as established by Beach Erosion law.

Cost sharing for the recreational navigation feature was based on local interests making a cash contribution of 50 percent of the first cost of the general navigation facilities based on present policy for small boat harbors. The Federal government would pay the entire cost of the commercial navigation feature of the plan.

The Federal and non-Federal shares of the total first cost are equal to the sum of their respective shares for the four separate functions of the multiple-purpose plan.

Maintenance and operation costs follow the usual practice for each function of the project. The local government would be required to take care of hurricane protection and beach protection features and the Federal government would maintain navigation features.

The cost allocation and cost apportionment, as given in Table F-1, are preliminary and would be subject to revision based on actual costs incurred in construction of the multiple-purpose project.

It may be noted also that the methods described required a tentative apportionment of costs using the $2\frac{5}{8}$ percent Federal and $3\frac{1}{2}$ percent non-Federal interest rates in order to compute the annual costs necessary for the cost allocation. Successive approximations were required until the calculated apportionment equalled the assumed apportionment between Federal and non-Federal costs. In the actual work sheets, all annual costs were computed to the nearest one dollar by the exact application of the interest and amortization rates to the investment costs, and all allocations and apportionments were obtained to the nearest one dollar. This was done so that an exact check could be made between the calculated and assumed apportionment and to avoid substantial "build-up" errors which might be in the four figure range. These work sheets have been incorporated into the office records. For presentation in the tables of this report all items of annual cost, allocation and apportionment have been rounded off to the nearest one hundred dollars.

TABLE F-1

COST ALLOCATION BETWEEN HURRICANE PROTECTION,
BEACH PROTECTION, COMMERCIAL NAVIGATION AND
RECREATIONAL NAVIGATION, EXCLUDING WAKEFIELD
CHANNEL AND ANCHORAGE AND COST APPORTIONMENT
BETWEEN FEDERAL AND NON-FEDERAL INTERESTS
(1961 Price Level)

POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Recreational Navigation</u>	<u>Multiple- Purpose Project</u>
<u>COST ALLOCATION</u>					
Average Annual Benefits Multiple-Purpose Project Cost (From Table F-23)	\$ 231,800	\$ 218,700	\$ 25,300	\$ 33,000	\$ 508,800
Alternative Project Costs (From Tables F-5, F-3, F-7, F-9)	190,100	47,100	18,600	27,500	283,300
Benefits Limited by Alter- native Costs	190,100	47,100	18,600	27,500	283,300
Three Purpose Projects Purpose	BP, CN & RN	HP, CN & RN	HP, BP & RN	HP, BP & CN	
Costs (From Tables F-21, F-23, F-18, F-17)	87,400	208,800	204,000	194,900	
Separable Costs	121,400	0	4,800	13,900	140,100
Remaining Benefits	68,700	47,100	13,800	13,600	143,200
Distribution Ratio for Joint Costs	48.0	32.9	9.6	9.5	100.0
Joint Costs	33,000	22,600	6,600	6,500	68,700
Total Allocation	154,400	22,600	11,400	20,400	208,800
Maintenance, Operation and Allowance for Major Replace- ments Total (From Table F-23)					79,400

Cont'd on Page F-7

TABLE F-1 (Cont'd)

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Recreational Navigation</u>	<u>Multiple Purpose Project</u>
Recreational Navigation (From Table F-9)				\$ 8,800	
Commercial Navigation (From Table F-7)			\$ 3,600		
H.P. & B.P. Combined (From Table F-5)	\$ 67,000				
Single Purpose H.P. & B.P. (From Tables F-5, F-3)	\$ 67,000	\$ 35,200			
Total Savings of Combined H.P. & B.P. Project Distrib- uted by Ratio of Savings in Total H.P. & B.P. Alternative Project Costs by Combined Project (From Table F-24)	17,600	17,600			
Total Maintenance, Opera- tion & Allowance for Major Replacements	49,400	17,600	3,600	8,800	79,400
Capital Costs Interest and Amortization	105,000	5,000	7,800	11,600	129,400
Investment Cost	2,757,600	123,700	215,800	295,900	3,393,000
Navigation Aids	6,000				6,000
Preauthorization Survey Studies	30,000	6,000	3,000	3,000	42,000
Subtotal - First Cost	2,721,600	117,700	212,800	292,900	3,345,000
<u>COST APPORTIONMENT</u>					
Federal Investment Cost	1,941,100	45,200	215,800	149,500	2,351,600
Non-Federal Invest, Cost	816,500	78,500	0	146,400	1,041,400

TABLE F-2

ESTIMATED FIRST COSTS
(1961 Price Level)

ALTERNATIVE BEACH PROTECTION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>BEACH</u>				
Sand Fill	90,000	c.y.	1.38	\$ 124,000
Rock Fill, Groins	8,930	c.y.	10.70	96,000
Sand Fence	7,700	l.f.	0.93	7,000
				<u>227,000</u>
Contingencies				<u>33,000</u>
TOTAL COST - BEACH				\$ 260,000
<u>ENGINEERING AND DESIGN</u>				8,000
<u>SUPERVISION AND ADMINISTRATION</u>				20,000
SUBTOTAL - FIRST COST				\$ 288,000(1)
Preauthorization Survey Studies				6,000
Estimated First Cost to U.S.				\$ 96,000
Estimated First Cost to Local Interests				\$ 192,000 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$250,000 for beach facilities.

TABLE F-3

ESTIMATED ANNUAL COSTS
(1961 Price Level)

ALTERNATIVE BEACH PROTECTION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs	\$102,000 (1)
<u>Federal Annual Costs</u>	
Interest on Investment, 2.625%	2,700
Amortization, 0.990%	<u>1,000</u>
Total Federal Annual Costs	\$ 3,700
<u>Non-Federal Investment Costs</u>	
Total Non-Federal Investment Costs	192,000
<u>Non-Federal Annual Costs</u>	
Interest on Investment, 3.5%	6,700
Amortization, 0.763%	<u>1,500</u>
Maintenance and Operation	
Sand Replacement	34,000
Groins Repair	<u>1,100</u>
Sand Fence Repair	<u>100</u>
Total Maintenance and Operation	<u>35,200</u>
Total Non-Federal Annual Costs	\$ 43,400
TOTAL ANNUAL COSTS	\$ 47,100

(1) Includes \$6,000 for preauthorization survey studies.

TABLE F-4

ESTIMATED FIRST COSTS
(1961 Price Level)
ALTERNATIVE HURRICANE PROTECTION PROJECT
INCLUDING BEACH PROTECTION
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>SITE PREPARATION</u>	\$ 5,000
<u>MATUNUCK BEACH</u>	
Earth Dike 10,000	
Rock Dike 176,000	
Road Relocation 17,000	
TOTAL COST-MATUNUCK BEACH 203,000	\$ 203,000
<u>MATUNUCK POINT</u>	
Rock Faced Sand Dike 161,000	
Rock Revetment 155,000	
TOTAL COST - MATUNUCK POINT 316 000	\$ 316,000
<u>EAST MATUNUCK BEACH</u>	
Sand Dike 538,000	
Beach 222,000	
Road Relocation 47,000	
TOTAL COST-EAST MATUNUCK BEACH 807,000	\$ 807,000
<u>BREACHWAY</u>	594,000
<u>GALILEE</u>	161,000
<u>SAND HILL COVE STATE BEACH AND SAND HILL COVE</u>	227,000
<u>LANDS AND DAMAGES</u>	450,000
<u>ENGINEERING AND DESIGN</u>	217,000
<u>SUPERVISION AND ADMINISTRATION</u>	204,000
SUBTOTAL - FIRST COST	\$3,184,000 (1)(2)
Navigation Aids 6,000	
Preauthorization Survey Studies 36,000	

Table F-4 (Cont'd on Page F-11)

TABLE F-4 Cont'd

Estimated First Cost to U.S.	\$2,177,000
Estimated First cost to Local Interests	1,007,000

- (1) Includes first cost of 65,000 c.y. of earth excavation dredging for relocation of entrance channel
- (2) Does not include first cost of required local interests' construction (self-liquidating) of \$250,000 for beach facilities.

TABLE F-5

ESTIMATED ANNUAL COSTS
(1961 Price Level)

ALTERNATIVE HURRICANE PROTECTION PROJECT
INCLUDING BEACH PROTECTION
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs (From Table F-24)	\$2,219,000 (1)
<u>Federal Annual Costs</u>	
Interest on Investment, 2.625%	58,200
Amortization, 0.990%	22,000
Maintenance and Operation	600
Total Federal Annual Costs	\$ 80,800
<u>Non-Federal Investment Costs</u>	
Contributed Funds	557,000
Lands and Damages	450,000
Total Non-Federal Investment Costs (From Table F-24)	\$1,007,000
<u>Non-Federal Annual Costs</u>	
Interest on Investment, 3.5%	35,200
Amortization 0.763%	7,700
Maintenance and Operation	64,600 (2)
Allowance for Major Replacements	1,800
Total Non-Federal Annual Costs	\$ 109,300
TOTAL ANNUAL COSTS	\$ 190,100

(1) Includes \$6,000 for navigation aids and
\$36,000 for preauthorization survey studies

(2) Duplicates existing maintenance of approximately \$6,700.

TABLE F-6

ESTIMATED FIRST COSTS
(1961 Price Level)

ALTERNATIVE COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>ENTRANCE CHANNEL</u>				
Earth Excavation, Dredging	220,000	c.y.	1.47	\$ 323,000
Contingencies				49,000
TOTAL COST - ENTRANCE CHANNEL				\$ 372,000
<u>ENGINEERING AND DESIGN</u>				9,000
<u>SUPERVISION AND ADMINISTRATION</u>				30,000
SUBTOTAL - FIRST COST				\$ 411,000
Preauthorization Survey Studies				3,000
Estimated First Cost to U.S.				\$ 411,000
Estimated First Cost to Local Interests				0

TABLE F-7

ESTIMATED ANNUAL COSTS
(1961 Price Level)

ALTERNATIVE COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs	\$ 411,000 (1)
<u>Federal Annual Costs</u>	
Interest on Investment 2.625%	10,900
Amortization, 0.990%	4,100
Maintenance and Operation	
Dredging Entrance Channel	3,600
Total Federal Annual Costs	\$ 18,600
TOTAL ANNUAL COSTS	\$ 18,600

(1) Includes \$3,000 for preauthorization survey studies

TABLE F-8

ESTIMATED FIRST COSTS
(1961 Price Level)

ALTERNATIVE RECREATIONAL NAVIGATION PROJECT,
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Quantity</u>	<u>Unit</u>	<u>Unit Price</u>	<u>Estimated Amount</u>
<u>INNER HARBOR ANCHORAGE</u>				
Earth Excavation, Dredging	56,500	c.y.	1.47	\$83,000
Contingencies				<u>12,000</u>
TOTAL COST - INNER HARBOR ANCHORAGE				\$95,000
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	54,000	c.y.	1.47	80,000
Contingencies				<u>12,000</u>
TOTAL COST - LITTLE COMFORT CHANNEL AND ANCHORAGE				\$ 92,000
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>				
Earth Excavation, Dredging	140,000	c.y.	1.47	206,000
Contingencies				<u>31,000</u>
TOTAL COST- SNUG HARBOR CHANNEL AND ANCHORAGE				\$ 237,000
<u>ENGINEERING AND DESIGN</u>				11,000
<u>SUPERVISION AND ADMINISTRATION</u>				37,000
SUBTOTAL - FIRST COST				\$ 472,000 (1)
Preauthorization Survey Studies				3,000
Estimated First Cost to U.S.				\$ 236,000
Estimated First Cost to Local Interests				\$ 236,000 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$40,000, of which \$20,000 is for public landings and \$20,000 is for spoil disposal areas.

TABLE F-9

ESTIMATED ANNUAL COSTS
(1961 Price Level)

ALTERNATIVE RECREATIONAL NAVIGATION PROJECT
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>		
Total Federal Investment Costs		\$ 239,000 (1)
<u>Federal Annual Costs</u>		
Interest on Investment, 2.625%		6,300
Amortization, 0.990%		2,300
Maintenance and Operation		
Dredging		
Inner Harbor Anchorage	1,300	
Little Comfort Channel and Anchorage	6,000	
Snug Harbor Channel and Anchorage	1,500	
Total Dredging	8,800	8,800
Total Federal Annual Costs		\$ 17,400
<u>Non-Federal Investment Costs</u>		
Total Non-Federal Investment Costs		\$ 236,000
<u>Non-Federal Annual Costs</u>		
Interest on Investment, 3.5%		8,300
Amortization, 0.763%		1,800
Total Non-Federal Annual Costs		\$ 10,100
TOTAL ANNUAL COSTS:		\$ 27,500

(1) Includes \$3,000 for preauthorization survey studies

TABLE F-10 .

ESTIMATED FIRST COSTS
(1961 Price Level)

BEACH PROTECTION AND COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>EAST MATUNUCK BEACH</u>	\$118,000
<u>ENTRANCE CHANNEL</u>	372,000
<u>ENGINEERING AND DESIGN</u>	17,000
<u>SUPERVISION AND ADMINISTRATION</u>	50,000
SUBTOTAL - FIRST COST	\$557,000 (1)
Preauthorization Survey Studies	9,000
Estimated First Cost to U.S.	\$409,700
Estimated First Cost to Local Interests	\$147,300 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$250,000 for beach facilities.

TABLE F-11

ESTIMATED ANNUAL COSTS
(1961 Price Level)

BEACH PROTECTION AND COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

Federal Investment Costs

Total Federal Investment Costs (From Table F-25)	\$ 418,700 (1)
---	----------------

Federal Annual Costs

Interest on Investment, 2.625%	11,000
Amortization, 0.990%	4,100
Maintenance and Operation	3,600
Total Federal Annual Costs	\$ 18,700

Non-Federal Investment Costs

Total Non-Federal Investment Costs (From Table F-25)	\$ 147,300
---	------------

Non-Federal Annual Costs

Interest on Investment, 3.5%	5,200
Amortization, 0.763%	1,100
Maintenance and Operation	35,200
Total Non-Federal Annual Costs	\$ 41,500

TOTAL ANNUAL COSTS	\$ 60,200
--------------------	-----------

(1) Includes \$9,000 for preauthorization survey studies

TABLE F-12

ESTIMATED FIRST COSTS
(1961 Price Level)

BEACH PROTECTION AND RECREATIONAL NAVIGATION PROJECT
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>EAST MATUNUCK BEACH</u>	\$118,000
<u>INNER HARBOR ANCHORAGE</u>	95,000
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>	92,000
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>	237,000
<u>ENGINEERING AND DESIGN</u>	19,000
<u>SUPERVISION AND ADMINISTRATION</u>	57,000
SUBTOTAL - FIRST COST	\$618,000 (1)
Preauthorization Survey Studies	9,000
Estimated First Cost to U.S.	\$272,700
Estimated First Cost to Local Interests	\$345,300 (1)

- (1) Does not include first cost of required local interests construction (self-liquidating) of \$290,000, of which \$250,000 is for beach facilities, \$20,000 is for public landings and \$20,000 is for spoil disposal areas.

TABLE F-13

ESTIMATED ANNUAL COSTS
(1961 Price Level)

BEACH PROTECTION AND RECREATIONAL NAVIGATION PROJECT
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs (From Table F-26)	\$ 281,700 (1)
<u>Federal Annual Costs</u>	
Interest on Investment, 2.625%	7,400
Amortization, 0.990%	2,800
Maintenance and Operation	8,800
Total Federal Annual Costs	\$ 19,000
<u>Non-Federal Investment Costs</u>	
Total Non-Federal Investment Costs (From Table F-26)	\$ 345,300
<u>Non-Federal Annual Costs</u>	
Interest on Investment, 3.5%	12,100
Amortization, 0.763%	2,600
Maintenance and Operation	35,200
Total Non-Federal Annual Costs	\$ 49,900
TOTAL ANNUAL COSTS	\$ 68,900

(1) Includes \$9,000 for preauthorization survey studies.

TABLE F-14

ESTIMATED FIRST COSTS
(1961 Price Level)

COMMERCIAL NAVIGATION AND RECREATIONAL NAVIGATION PROJECT
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>ENTRANCE CHANNEL</u>	\$ 372,000
<u>INNER HARBOR ANCHORAGE</u>	\$ 95,000
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>	\$ 92,000
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>	\$ 237,000
<u>ENGINEERING AND DESIGN</u>	\$ 20,000
<u>SUPERVISION AND ADMINISTRATION</u>	\$ 67,000
SUBTOTAL - FIRST COST	\$ 883,000 (1)
Preauthorization Survey Studies	6,000
Estimated First Cost to U.S.	\$ 647,000
Estimated First Cost to Local Interests	\$ 236,000 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$40,000, of which \$20,000 is for public landings and \$20,000 is for spoil disposal areas.

TABLE F-15

ESTIMATED ANNUAL COSTS
(1961 Price Level)

COMMERCIAL NAVIGATION AND RECREATIONAL NAVIGATION PROJECT
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>	
Total Federal Investment Costs	\$ 653,000 (1)
<u>Federal Annual Costs</u>	
Interest on Investment, 2.625%	17,100
Amortization, 0.990%	6,500
Maintenance and Operation	<u>12,400</u>
Total Federal Annual Costs	\$ <u>36,000</u>
<u>Non-Federal Investment Costs</u>	
Total Non-Federal Investment Costs	\$ 236,000
<u>Non-Federal Annual Costs</u>	
Interest on Investment, 3.5%	8,300
Amortization, 0.763%	<u>1,800</u>
Total Non-Federal Annual Costs	\$ <u>10,100</u>
TOTAL ANNUAL COSTS	\$ 46,100

(1) Includes \$6,000 preauthorization survey studies.

TABLE F-16

ESTIMATED FIRST COSTS
(1961 Price Level)
HURRICANE PROTECTION. BEACH PROTECTION AND COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>SITE PREPARATION</u>	\$ 5,000
<u>MATUNUCK BEACH</u>	
Earth Dike	10,000
Rock Dike	176,000
Road Relocation	17,000
TOTAL COST - MATUNUCK BEACH	203,000
<u>MATUNUCK POINT</u>	
Rock Faced Sand Dike	161,000
Rock Revetment	155,000
TOTAL COST - MATUNUCK POINT	316,000
<u>EAST MATUNUCK BEACH</u>	
Sand Dike	538,000
Beach	222,000
Road Relocation	47,000
TOTAL COST - EAST MATUNUCK BEACH	807,000
<u>BREACHWAY</u>	594,000
<u>GALILEE</u>	161,000
<u>SAND HILL COVE STATE BEACH AND SAND HILL COVE</u>	227,000
<u>ENTRANCE CHANNEL</u> (Included in cost of sand fill for beach and dikes)	
<u>LANDS AND DAMAGES</u>	450,000
<u>ENGINEERING AND DESIGN</u>	226,000
<u>SUPERVISION AND ADMINISTRATION</u>	234,000
SUBTOTAL - FIRST COST	\$3,223,000 (1)
Navigation Aids	6,000
Preauthorization Survey Studies	39,000
Estimated First Cost to U.S.	\$2,277,400
Estimated First Cost to Local Interests	\$ 945,600 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$250,000 for beach facilities.

TABLE F-17

ESTIMATED ANNUAL COSTS
(1961 Price Level)

HURRICANE PROTECTION, BEACH PROTECTION AND COMMERCIAL NAVIGATION PROJECT
POINT JUDITH, RHODE ISLAND

Federal Investment Costs

Total Federal Investment Costs (From Table F-27)	\$ 2,322,400 (1)
---	------------------

Federal Annual Costs

Interest on Investment, 2.625%	61,000
Amortization, 0.990%	23,000
Maintenance and Operation	<u>4,200</u>
Total Federal Annual Costs	\$ 88,200

Non-Federal Investment Costs

Contributed Funds	495,600
Lands and Damages	<u>450,000</u>
Total Non-Federal Investment Costs (From Table F-27)	\$ 945,600

Non-Federal Annual Costs

Interest on Investment, 3.5%	33,100
Amortization, 0.763%	7,200
Maintenance and Operation	64,600 (2)
Allowance for Major Replacements	<u>1,800</u>
Total Non-Federal Annual Costs	\$ 106,700

TOTAL ANNUAL COSTS	\$ 194,900
--------------------	------------

- (1) Includes \$6,000 for navigation aids and \$39,000 for preauthorization survey studies.
- (2) Duplicates existing maintenance of approximately \$6,700.

TABLE F-18

ESTIMATED FIRST COSTS
(1961 Price Level)

HURRICANE PROTECTION, BEACH PROTECTION AND RECREATIONAL NAVIGATION
PROJECT, EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE

POINT JUDITH, RHODE ISLAND

<u>Item</u>		<u>Estimated Amount</u>
<u>SITE PREPARATION</u>		\$ 5,000
<u>MATUNUCK BEACH</u>		
Earth Dike	\$ 10,000	
Rock Dike	177,000	
Road Relocation	17,000	
TOTAL COST - MATUNUCK BEACH	<u>204,000</u>	\$ 204,000
<u>MATUNUCK POINT</u>		
Rock faced Sand Dike	164,000	
Rock Revetment	155,000	
TOTAL COST - MATUNUCK POINT	<u>319,000</u>	\$ 319,000
<u>EAST MATUNUCK BEACH</u>		
Sand Dike	587,000	
Beach	231,000	
Road Relocation	49,000	
TOTAL COST - EAST MATUNUCK BEACH	<u>867,000</u>	\$ 867,000
<u>BREACHWAY</u>		594,000
<u>GALILEE</u>		161,000
<u>SAND HILL COVE STATE BEACH AND SAND HILL COVE</u>		237,000
<u>INNER HARBOR ANCHORAGE</u> (Included in cost of sand fill for beach and dikes)		
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u> (Included in cost of sand fill for beach and dikes)		
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u> (Included in cost of sand fill for beach and dikes)		
<u>LANDS AND DAMAGES</u>		450,000
<u>ENGINEERING AND DESIGN</u>		228,000
<u>SUPERVISION AND ADMINISTRATION</u>		241,000

Table F-18 Cont'd on Page F-25

TABLE F-18 (Cont'd)

ESTIMATED FIRST COSTS
 (1961 Price Level)
HURRICANE PROTECTION, BEACH PROTECTION AND RECREATIONAL NAVIGATION
PROJECT, EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
SUBTOTAL - FIRST COST	\$ 3,306,000 (1)
Navigation Aids	6,000
Preauthorization Survey Studies	39,000
Estimated First Cost to U.S.	\$ 2,214,700
Estimated First Cost to Local Interests	\$ 1,091,300

- (1) Does not include first cost of required local interests construction (self-liquidating) of \$290,000, of which \$250,000 is for beach facilities, \$20,000 is for public landings and \$20,000 is for spoil disposal areas.

TABLE F-19

ESTIMATED ANNUAL COSTS
(1961 Price Level)

HURRICANE PROTECTION, BEACH PROTECTION AND RECREATIONAL NAVIGATION
PROJECT, EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

Federal Investment Costs

Total Federal Investment Costs (From Table F-28)	\$ 2,259,700 (1)
---	------------------

Federal Annual Costs

Interest on Investment, 2.625%	59,300
Amortization, 0.990%	22,400
Maintenance and Operation	9,400
Total Federal Annual Costs	\$ 91,100

Non-Federal Investment Costs

Contributed Funds	641,300
Lands and Damages	450,000
Total Non-Federal Investment Costs (From Table F-28)	\$ 1,091,300

Non-Federal Annual Costs

Interest on Investment, 3.5%	38,200
Amortization, 0.763%	8,300
Maintenance and Operation	64,600
Allowance for Major Replacements	1,800
Total Non-Federal Annual Costs	\$ 112,900

TOTAL ANNUAL COSTS	\$ 204,000
--------------------	------------

- (1) Includes \$6,000 for navigation aids and \$39,000 for preauthorization survey studies.

TABLE F-20

ESTIMATED FIRST COSTS
(1961 Price Level)

BEACH PROTECTION, COMMERCIAL NAVIGATION AND RECREATIONAL NAVIGATION
PROJECT, EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Estimated Amount</u>
<u>EAST MATUNUCK BEACH</u>	\$ 118,000
<u>ENTRANCE CHANNEL</u>	372,000
<u>INNER HARBOR ANCHORAGE</u>	95,000
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>	92,000
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>	237,000
<u>ENGINEERING AND DESIGN</u>	28,000
<u>SUPERVISION AND ADMINISTRATION</u>	87,000
SUBTOTAL - FIRST COST	\$ 1,029,000
Preauthorization Survey Studies	12,000
Estimated First Cost to U.S.	\$ 693,400
Estimated First Cost to Local Interests	\$ 335,600

TABLE F-21

ESTIMATED ANNUAL COSTS
(1961 Price Level)
BEACH PROTECTION, COMMERCIAL NAVIGATION AND RECREATIONAL NAVIGATION
PROJECT, EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE
POINT JUDITH, RHODE ISLAND

<u>Federal Investment Costs</u>		
Total Federal Investment Costs	\$ 705,400	(1)
(From Table F-29)		
<u>Federal Annual Costs</u>		
Interest on Investment, 2.625%	18,500	
Amortization, 0.990%	7,000	
Maintenance and Operation	12,400	
Total Federal Annual Costs	37,900	
<u>Non-Federal Investment Costs</u>		
Total Non-Federal Investment Costs	\$ 335,600	
(From Table F-29)		
<u>Non-Federal Annual Costs</u>		
Interest on Investment, 3.5%	11,700	
Amortization, 0.763%	2,600	
Maintenance and Operation	35,200	
Total Non-Federal Annual Costs	\$ 49,500	
TOTAL ANNUAL COSTS	\$ 87,400	

TABLE F-22

ESTIMATED FIRST COSTS
(1961 Price Level)

WATER RESOURCES DEVELOPMENT PLAN, EXCLUDING WAKEFIELD
CHANNEL AND ANCHORAGE. POINT JUDITH, RHODE ISLAND

<u>Item</u>		<u>Estimated Amount</u>
<u>SITE PREPARATION</u>		\$ 5,000
<u>MATUNUCK BEACH</u>		
Earth Dike	10,000	
Rock Dike	177,000	
Road Relocation	17,000	
TOTAL COST - MATUNUCK BEACH	204,000	\$ 204,000
<u>MATUNUCK POINT</u>		
Rock Faced Sand Dike	164,000	
Rock Revetment	155,000	
TOTAL COST - MATUNUCK POINT	319,000	\$ 319,000
<u>EAST MATUNUCK BEACH</u>		
Sand Dike	587,000	
Beach	231,000	
Road Relocation	49,000	
TOTAL COST - EAST MATUNUCK BEACH	867,000	\$ 867,000
<u>BREACHWAY</u>		594,000
<u>GALILEE</u>		161,000
<u>SAND HILL COVE STATE BEACH AND SAND HILL COVE</u>		237,000
<u>ENTRANCE CHANNEL</u>	(Included in cost of sand fill for beach and dikes)	
<u>INNER HARBOR ANCHORAGE</u>	(Included in cost of sand fill for beach and dikes)	
<u>LITTLE COMFORT CHANNEL AND ANCHORAGE</u>	(Included in cost of sand fill for beach and dikes)	
<u>SNUG HARBOR CHANNEL AND ANCHORAGE</u>	(Included in cost of sand fill for beach and dikes)	

Table F-22 Cont'd on Page F-30

TABLE F-22 (Cont'd)

ESTIMATED FIRST COSTS
(1961 Price Level)

<u>LANDS AND DAMAGES</u>	\$ 450,000
<u>ENGINEERING AND DESIGN</u>	237,000
<u>SUPERVISION AND ADMINISTRATION</u>	271,000
SUBTOTAL - FIRST COST	3,345,000 (1)
Navigation Aids	6,000
Preauthorization Survey Studies	42,000
Estimated First Cost to U.S.	2,303,600
Estimated First Cost to Local Interests	1,041,400 (1)

- (1) Does not include first cost of required local interests' construction (self-liquidating) of \$290,000, of which \$250,000 is for beach facilities, \$20,000 is for public landings and \$20,000 for spoil areas.

TABLE F-23

ESTIMATED ANNUAL COSTS
(1961 Price Level)

WATER RESOURCES DEVELOPMENT PLAN, EXCLUDING WAKEFIELD
CHANNEL AND ANCHORAGE, POINT JUDITH, RHODE ISLAND

Federal Investment Costs

Total Federal Investment Costs (From Table F-1)	\$ 2,351,600	(1)
--	--------------	-----

Federal Annual Costs

Interest on Investment, 2.625%	61,700	
Amortization, 0.990%	23,300	
Maintenance and Operation	13,000	
Total Federal Annual Costs	\$ 98,000	

Non-Federal Investment Costs

Contributed Funds	591,400	
Lands and Damages	450,000	
Total Non-Federal Investment Costs (From Table F-1)	\$ 1,041,400	

Non-Federal Annual Costs

Interest on Investment, 3.5%	36,500	
Amortization, 0.763%	7,900	
Maintenance and Operation	64,600	
Allowance for Major Replacements	1,800	
Total Non-Federal Annual Costs	\$ 110,800	

TOTAL ANNUAL COSTS

	\$ 208,800	
--	------------	--

- (1) Includes \$6,000 for navigation aids and \$42,000 for preauthorization survey studies

TABLE F-24
COST ALLOCATION BETWEEN HURRICANE PROTECTION AND BEACH PROTECTION
AND COST APPORTIONMENT BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.
 (1961 Price Level)
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>			
Average Annual Benefits	\$ 231,800 (1)	\$218,700	\$ 450,500
Combined Project Cost (Table F-5)			190,100
Alternative Proj. Costs (F-5, F-3)	190,100 (2)	47,100	237,200
Benefits Limited by Alternative Costs	190,100	47,100	237,200
Single-Purpose Project			
Purpose	B.P.	H.P.	
Costs (From Tables F-3, F-5)	47,100	190,100	
Separable Costs	143,000	0	143,000
Remaining Benefits	47,100	47,100	94,200
Distribution Ratio for Joint Costs	50.0	50.0	100.0
Joint Costs	23,600	23,500	47,100
Total Allocations	166,600	23,500	190,100
Savings in Alternative Project			
Costs by Combined Project	23,500	23,600	47,100
Percent Savings in Alternative			
Project Costs by Combined Project	50.0	50.0	100.0
Maintenance Operations and Allowance for Major Replacements			
Single Purpose H.P. & B.P. (From Tables F-5 F-3)	67,000	35,200	102,200
Total Savings of Combined Project			
Distributed by Ratio of Savings in Total Alternative Project Costs by Combined Project	17,600	17,600	35,200
Total Maintenance, Operation and Allowance for Major Replacements	49,400	17,600	67,000
Capital Costs-Interest & Amortiz.	117,200	5,900	123,100
Investment Cost	3,078,700	147,300	3,226,000
Navigation Aids	6,000	0	6,000
Preauthorization Survey Studies	30,000	6,000	36,000
Subtotal - First Cost	\$3,042,700	\$141,300	\$3,184,000
<u>COST APPORTIONMENT</u>			
Federal Investment Cost	\$2,165,900	\$ 53,100	\$2,219,000
Non-Federal Investment Cost	\$ 912,800	\$ 94,200	\$1,007,000

- (1) Net figure of \$231,800 is used for allocation, so as not to duplicate beach protection features, \$218,700
- (2) Includes beach protection features, \$47,100.

TABLE F-25

COST ALLOCATION BETWEEN BEACH PROTECTION AND COMMERCIAL NAVIGATION
AND COST APPORTIONMENT BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.

(1961 Price Level)
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>			
Average Annual Benefits	\$ 218,700	\$ 25,300	\$ 244,000
Combined Project Cost (Table F-11)			60,200
Alternative Project Costs (F-3, F-7)	47,100	18,600	65,700
Benefits Limited by Alternative Costs	47,100	18,600	65,700
Single-Purpose Project			
Purpose	C.N.	B.P.	
Costs (From Tables F-7, F-3)	18,600	47,100	
Separable Costs	41,600	13,100	54,700
Remaining Benefits	5,500	5,500	11,000
Distribution Ratio for Joint Costs	50.0	50.0	100.0
Joint Costs	2,800	2,700	5,500
Total Allocation	44,400	15,800	60,200
Maintenance and Operation (From Tables F-3, F-7, F-11)	35,200	3,600	38,800
Capital Costs-Interest and Amortiz.	9,200	12,200	21,400
Investment Cost	227,000	339,000	566,000
Preauthorization Survey Studies	6,000	3,000	9,000
Subtotal - First Cost	\$ 221,000	\$336,000	\$557,000
<u>COST APPORTIONMENT</u>			
Federal Investment Cost	\$ 79,700	\$339,000	\$418,700
Non-Federal Investment Cost	\$ 147,300	0	\$147,300

TABLE F-26

COST ALLOCATION BETWEEN BEACH PROTECTION AND RECREATIONAL NAVIGATION,
EXCLUDING WAKEFIELD CHANNEL AND ANCHORAGE AND COST APPORTIONMENT
BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.

(1961 Price Level)

POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Beach Protection</u>	<u>Recreational Navigation</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>			
Average Annual Benefits	\$ 218,700	\$ 33,000	\$ 251,700
Combined Project Cost (From Table F-13)			68,900
Alternative Project Costs (From Tables F-3, F-9)	47,100	27,500	74,600
Benefits limited by Alternative Costs	47,100	27,500	74,600
Single-Purpose Project			
Purpose	R.N.	B.P.	
Costs (From Tables F-9, F-3)	27,500	47,100	
Separable Costs	41,400	21,800	63,200
Remaining Benefits	5,700	5,700	11,400
Distribution Ratio for Joint Costs	50.0	50.0	100.0
Joints Costs	2,800	2,900	5,700
Total Allocation	44,200	24,700	68,900
Maintenance and Operation (F-8, F-9)	35,200	8,800	44,000
Capital Costs, Interest and Amortiz.	9,000	15,900	24,900
Investment Cost	223,900	403,100	627,000
Preauthorization Survey Studies	6,000	3,000	9,000
Subtotal - First Cost	\$217,900	\$400,100	\$618,000
<u>COST APPORTIONMENT</u>			
Federal Investment Cost	\$ 78,600	\$203,100	\$281,700
Non-Federal Investment Cost	\$145,300	\$200,000	\$345,300

TABLE F-27

COST ALLOCATION BETWEEN HURRICANE PROTECTION, BEACH
PROTECTION AND COMMERCIAL NAVIGATION AND COST APPOR-
TIONMENT BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.

(1961 Price Level)

POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>				
Average Annual Benefits	\$ 231,800(1)	\$ 218,700	\$ 25,300	\$ 475,800
Combined Project Cost (From Table F-17)				194,900
Alternative Project Costs				
(From Tables F-5, F-3, F-7)	190,100(2)	47,100	18,600	255,800
Benefits Limited by Alternative Costs	190,100	47,100	18,600	255,800
Two-Purpose Projects				
Purpose	B.P. & C.N.	H.P. & C.N.	H.P. & B.P.	
Costs (From Tables F-11, F-17, F-5)	60,200	194,900	190,100	
Separable Costs	134,700	0	4,800	139,500
Remaining Benefits	55,400	47,100	13,800	116,300
Distribution Ratio for Joint Costs	47.7	40.4	11.9	100.0
Joint Costs	26,400	22,400	6,600	55,400
Total Allocation	161,100	22,400	11,400	194,900
Maintenance, Operation and Allowance				
for Major Replacements				
Total (From Table F-17)				70,600
Commercial Navigation (From Table F-7)			3,600	
H.P. and B.P. Combined (From Table F-5)	67,000			
Single Purpose H.P. and B.P.				
(From Tables F-5, F-3)	67,000	35,200		

Table F-27 Cont'd on Page F-36

TABLE F-27 (Cont'd)

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Combined Project</u>
Total Savings of Combined Hurricane Protection and Beach Protection Project Distributed by Ratio of Savings in Total Hurricane Protection and Beach Protection Alternative Project Costs by Combined Project (From Table F-24)	17,600	17,600		
Total Maintenance, Operation and Allowance for Major Replacements	49,400	17,600	3,600	70,600
Capital Costs - Interest and Amortiza.	111,700	4,800	7,800	124,300
Investment Cost	2,934,200	120,200	213,600	3,268,000
Navigation Aids	6,000			6,000
Preauthorization Survey Studies	30,000	6,000	3,000	39,000
Subtotal - First Cost	\$ 2,898,200	\$ 114,200	\$ 210,600	\$ 3,223,000

COST APPORTIONMENT

Federal Investment Cost	\$ 2,064,700	\$ 44,100	\$ 213,600	\$ 2,322,400
Non-Federal Investment Cost	\$ 869,500	\$ 76,100	0	945,600

- (1) Net figure of \$231,800 is used for allocation, so as not to duplicate beach protection features, \$218,700
- (2) Includes beach protection features, \$47,100.

TABLE F-28

COST ALLOCATION BETWEEN HURRICANE PROTECTION, BEACH
PROTECTION AND RECREATIONAL NAVIGATION, EXCLUDING
WAKEFIELD CHANNEL AND ANCHORAGE AND COST APPORTION-
MENT BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.

(1961 Price Level)
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Recreational Navigation</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>				
Average Annual Benefits	\$ 231,800(1)	\$ 218,700	\$ 33,000	\$ 483,500
Combined Project Cost (From Table F-19)				204,000
Alternative Project Costs				
(From Tables F-5, F-3, F-9)	190,100 (2)	47,100	27,500	264,700
Benefits Limited by Alternative Costs	190,100	47,100	27,500	264,700
Two Purpose Projects				
Purpose	B.P. & R.N.	H.P. & R.N.	H.P. & B.P.	
Costs (From Tables F-13, F-19, F-5)	68,900	204,000	190,100	
Separable Costs	135,100	0	13,900	149,000
Remaining Benefits	55,000	47,100	13,600	115,700
Distribution Ratio for Joint Costs	47.5	40.7	11.8	100.0
Joint Costs	26,200	22,400	6,400	55,000
Total Allocation	161,300	22,400	20,300	204,000
Maintenance Operation and Allowance				
for Major Replacements				
Total (From Table F-19)				75,800
Recreational Navigation (From Table F-9)			8,800	
H.P. and B.P. Combined (From Table F-5)		67,000		
Single Purpose H.P. and B.P.				
(From Tables F-5, F-3)	67,000	35,200		

Table F-28 Cont'd on Page F-38

TABLE F-28 Cont'd

<u>Item</u>	<u>Hurricane Protection</u>	<u>Beach Protection</u>	<u>Recreational Protection</u>	<u>Combined Project</u>
Total Savings of Combined Hurricane Protection and Beach Protection Project Distributed by Ratio of Savings in Total Hurricane Protection and Beach Protection Alternative Project Costs by Combined Project (From Table F-24)	17,600	17,600		
Total Maintenance, Operation and Allowance for Major Replacements	49,400	17,600	8,800	75,800
Capital Costs, Interest and Amortization	111,900	4,800	11,500	128,200
Investment Cost	2,938,700	118,800	293,500	3,351,000
Navigation Aids	6,000			6,000
Preauthorization Survey Studies	30,000	6,000	3,000	39,000
Subtotal - First Cost	\$2,902,700	\$ 112,800	\$ 290,500	\$3,306,000
<u>COST APPORTIONMENT</u>				
Federal Investment Cost	\$2,067,900	\$ 43,600	\$ 148,200	\$2,259,700
Non-Federal Investment Cost	\$ 870,800	\$ 75,200	\$ 145,300	\$1,091,300

- (1) Net figure of \$231,800 is used for allocation, so as not to duplicate beach protection features, \$218,700.
- (2) Includes beach protection features \$47,100.

TABLE F-29

COST ALLOCATION BETWEEN BEACH PROTECTION, COMMERCIAL
NAVIGATION AND RECREATIONAL NAVIGATION, EXCLUDING
WAKEFIELD CHANNEL AND ANCHORAGE AND COST APPORTION-
MENT BETWEEN FEDERAL AND NON-FEDERAL INTERESTS.

(1961 Price Level)
POINT JUDITH, RHODE ISLAND

<u>Item</u>	<u>Beach Protection</u>	<u>Commercial Navigation</u>	<u>Recreational Navigation</u>	<u>Combined Project</u>
<u>COST ALLOCATION</u>				
Average Annual Benefits	\$ 218,700	\$ 25,300	\$ 33,000	\$ 277,000
Combined Project Cost (From Table F-21)				87,400
Alternative Project Costs				
(From Tables F-3, F-7, F-9)	47,100	18,600	27,500	93,200
Benefits Limited by Alternative Costs	47,100	18,600	27,500	93,200
Two Purpose Projects				
Purpose	C.N. & R.N.	B.P. & R.N.	B.P. & C.N.	
Costs (From Tables F-15, F-13, F-11)	46,100	68,900	60,200	
Separable Costs	41,300	18,500	27,200	87,000
Remaining Benefits	5,800	100	300	6,200
Distribution Ratio for Joint Costs	93.9	1.0	5.1	100.0
Joint Costs	400	0	0	400
Total Allocation	41,700	18,500	27,200	87,400
Maintenance and Operation	35,200	3,600	8,800	47,600
(From Tables F-3, F-7, F-9)				
Capital Costs-Interest and Amortization	6,500	14,900	18,400	39,800
Investment Cost	161,000	412,400	467,600	1,041,000
Preauthorization Survey Studies	6,000	3,000	3,000	12,000
Subtotal- First Cost	\$ 155,000	\$ 409,400	\$ 464,600	\$ 1,029,000
<u>COST APPORTIONMENT</u>				
Federal Investment Cost	\$ 57,700	\$ 412,400	\$ 235,300	\$ 705,400
Non-Federal Investment Cost	\$ 103,300	\$ 0	\$ 232,300	\$ 335,600

APPENDIX G
FLOOD LOSSES AND BENEFITS

APPENDIX G

APPENDIX G

FLOOD LOSSES AND BENEFITS

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
GENERAL		
G-1	Damage Surveys	G-1
G-2	Loss Classifications	G-1
HURRICANE TIDAL-FLOOD DAMAGE		
G-3	Tidal-Flood Losses	G-2
G-4	Type and Distribution of Losses	G-2
G-5	Recurring Losses	G-5
ANNUAL LOSSES AND BENEFITS		
G-6	General	G-5
G-7	Average Annual Tidal-Flood Losses	G-5
G-8	Average Annual Flood Damage Prevention Benefits	G-6
G-9	Emergency Cost Benefits	G-7
G-10	Navigation and Prevention of Boat Damages	G-7
G-11	Beach Erosion Prevention	G-7
G-12	Enhancement	G-7
G-13	Summary of Benefits	G-9
G-14	Growth Trends in Point Judith Area	G-9

TABLES

<u>Number</u>		
G-1	Experienced Tidal-Flood Losses, Point Judith Area - 1954	G-4
G-2	Hurricane Tidal-Flood Damages	G-5
G-3	Annual Flood-Damage Prevention Benefits	G-6
G-4	Enhancement Development	G-8

PLATES

G-1	Flood Area and Damages
G-2	Curves for Economic Analysis

APPENDIX G

FLOOD LOSSES AND BENEFITS

GENERAL

G-1. DAMAGE SURVEYS

Reconnaissance damage surveys were conducted in the Point Judith area immediately after the August 1954 hurricane and followed with more detailed surveys late in 1956. Essentially, the latter damage surveys were door-to-door inspections of residential, commercial and industrial properties affected by tidal flooding.

Additional data were furnished by local officials and other central sources. The information obtained included the extent and character of the area flooded, descriptions of the properties including changes since 1954, the nature and amount of damages, depths of flooding, high-water references and relationships between 1954 and previous flood stages. Estimates of losses were furnished by property owners or tenants and were used when they appeared reasonable. In other cases, losses were modified by the investigators, on the basis of data developed in the survey. Sampling methods were used where properties of the same general type were subject to the same depth of flooding. The survey covered (1) the 3 mile coastal area fronting on Block Island Sound from Matunuck Beach in South Kingstown to Sand Hill Cove in Narragansett, (2) the 16-miles of shoreline enclosing Point Judith, Potter and Upper Ponds, (3) the islands of Harbour Island, Great Island and Ram Island, and (4) the tidewater portion of the Saugatuckett River upstream to U. S. Route 1.

Sufficient data were obtained to derive losses at the 1954 flood level, and at a stage 3 feet higher. Zero damage, or the stage where damage begins referenced to the 1954 flood and stages at which marked increases in damages occur, were also determined.

G-2. LOSS CLASSIFICATIONS

Flood loss information was recorded by type of loss and by location. The type of losses recorded included urban (commercial, residential, and public), industrial, highway, and utility.

The losses in the survey were tangible, primary damages comprising the following (1) physical losses, such as damage to structures, machinery and stock, and cost of cleanup and repairs, and (2) non-physical losses, such as unrecovered loss of business, wages or production, increased cost of operation, cost of temporary facilities and increased cost of shipment of goods into or out of the inundated areas.

The primary loss resulting from physical damage and a large part of the related non-physical loss, were determined by direct inspection of flooded properties and evaluation of the losses by either property owners or field investigators, or both. Where non-physical losses were difficult to estimate on the basis of available information, estimates utilizing relationships between physical and non-physical losses for similar properties in the area were used. No evaluations were made of intangible losses, including such items as hazards to life, health and personal security.

HURRICANE TIDAL - FLOOD DAMAGES

G-3. TIDAL FLOOD LOSSES

The combination of the 1954 August hurricane surge and predicted high tides forced tidal waters over natural barriers into flood prone areas in the Point Judith area causing damages of \$3,340,000. Over 730 structures suffered tidal flood damages, including some 700 year-round homes; rental properties and summer cottages; 30 commercial establishments (including 4 major boat yards), public and private piers; and a large dehydrating process plant. Of these, 150 structures were partially or completely destroyed. Damage areas are described in Table G-1 and are shown on Plate G-1.

G-4. TYPE AND DISTRIBUTION OF LOSSES

Approximately 50% of the total tidal flood-damage experienced during the August 1954 hurricane was sustained by some 700 dwellings that border the shorelines of the Point Judith area. The remaining losses were distributed among the year-round fishing industry and the commercial interests geared to the summer tourist trade. A tabulation of 1954 experienced tidal-flood losses in the South Kingstown and Narragansett portion of the Point Judith area is shown in Table G-1 by damage areas and by type of losses.

In Area I, which includes Matunuck, East Matunuck and Succotash Road to the highway bridge, losses caused by tidal flooding during the 1954 hurricane amounted to about \$540,000. Some 120 homes and summer cottages in East Matunuck were totally destroyed when tidal flood waters rushed over Succotash Road. The full force of on-rushing water proved too much for the Succotash Road Bridge which finally collapsed into Potter Pond isolating several families from the mainland. After many rescues, a State trooper succumbed to the rising tides accounting for one of the 5 storm fatalities in the South Kingstown-Narragansett area. In Matunuck itself, some 63 homes and summer cottages experienced flooding up to depths of 2 feet over ground floors. Cottages in this area would undoubtedly wash away with slightly higher flood stages.

In Area II, which includes Snug Harbor to Turner Cove, 96 dwellings and 6 commercial establishments including a boat yard and a public bath house, sustained losses amounting to about \$280,000. Many of the cottages experienced depths of flooding up to 2 feet. Piers jutting out into Point Judith Pond were severely damaged when buildings swept from Jerusalem and Matumuck and floating craft smashed about on the hurricane surge. Several cottages on the west side of Succotash Road were washed into Potter Road.

In Area III, from Turner Cove to the northerly town line, losses amounted to \$360,000. Nearly all of the 29 residential properties and 5 commercial establishments in the flood prone area are located in the one and a half mile reach from Short Point to the town line. Tidal flooding occurred as far north as the U. S. Route 1 Bridge over the Saugatuckett River in Wakefield, some 4 miles from the Breachway entrance in the harbor. Two apartment buildings, an automobile agency, and a hardware store experienced full basement flooding at this point. On the northern end of Upper Pond, the laboratories and offices of the Gazda Engineering Company were severely damaged forcing the company out of business. Not far from Gazda, Hanson's Boat Yard suffered extensive damage to its piers and buildings when craft broke loose from their moorings and crashed into the structures.

Area IV, which includes Jerusalem, Galilee and Sand Hill Cove, experienced the largest amount of damage in the project area. Approximately 220 all-year dwellings, rental properties and summer cottages, 17 commercial establishments, and the industrial firm of the Point Judith Dehydrating Company suffered damages totaling \$1,890,000. Concentrations of firms engaged in the fishing industry on both sides of the Breachway experienced depths of flooding up to 4 feet over first floor levels. On the Jerusalem side of the Breachway, some 100 houses were washed off foundations. Of these, 70 remained sufficiently structurally sound to be restored to their original positions. Less fortunate were 30 homes which were totally destroyed. In the residential section of Sand Hill Cove, depths up to 3 feet over first floor levels were noted. Here, 6 of the 40 dwellings washed off foundations were totally destroyed. In addition to residential and commercial damage, losses totaling about \$200,000 were sustained by the numerous state-owned piers that jut out from both sides of the Breachway.

In Area V, which includes Great Island and the east coast of Point Judith Pond from Bluff Hill Cove to Welcome Cove, some 100 all-year dwellings and summer cottages experienced tidal flooding amounting to \$180,000. Eighty percent of the houses damaged are located on Great Island while the remainder are found on the less developed mainland area. Of the total number of houses on Great Island, approximately 40 percent are susceptible to tidal flooding.

TABLE G-1

EXPERIENCED TIDAL FLOOD LOSSESPOINT JUDITH AREA -- 1954SOUTH KINGSTOWN AND NARRAGANSETT, RHODE ISLAND

		<u>LOSSES IN THOUSANDS OF DOLLARS</u>				
<u>AREA</u>	<u>DESCRIPTION</u>	<u>RESIDENTIAL</u>	<u>COMMERCIAL</u>	<u>INDUSTRIAL</u>	<u>PUBLIC</u>	<u>TOTAL</u>
<u>South Kingstown</u>						
I	Matunuck, East Matunuck and Succotash Road	504.0	13.0	-	23.0	540.0
II	Snug Harbor to Turner Cove	212.0	64.0	-	4.0	280.0
III	Turner Cove to northerly Town Line	<u>53.0</u>	<u>303.0</u>	-	<u>4.0</u>	<u>360.0</u>
	Subtotal	769.0	380.0		31.0	1,180.0
<u>Narragansett</u>						
IV	Jerusalem, Galilee and Sand Hill Cove	865.0	378.0	500.0	147.0	1,890.0
V	Great Island; Bluff Hill Cove to Welcome Cove	180.0	-	-	-	180.0
VI	Harbour Island; Welcome Cove to northerly Town Line	<u>88.0</u>	<u>-</u>	<u>-</u>	<u>2.0</u>	<u>90.0</u>
	Subtotal	1,133.0	378.0	500.0	149.0	2,160.0
	Totals	1,902.0	758.0	500.0	180.0	3,340.0

In Area VI, which includes Ram Island, Harbour Island, and the eastern shoreline of Point Judith Pond from Wolcott Cove to the northerly town line, some 38 dwellings and cottages suffered tidal-flood damages amounting to \$90,000. Eighty percent of this damage occurred on Ram Island and Harbour Island which are more fully developed than the mainland.

G-5. RECURRING LOSSES

Stage-damage curves, referenced to the 1954 tidal-flood level, were prepared from data obtained from recent damage surveys and office estimates. These stage-loss curves afford a means of determining the magnitude of recurring losses up to a stage 3-feet higher than that experienced in 1954. The recurring losses at the various stages reflect economic and physical changes in the area since 1954. A breakdown of losses in the Point Judith Protection Plan, in the event of future hurricanes, are shown in Table G-2.

TABLE G-2

RECURRING TIDAL-FLOOD DAMAGES (1961 Price Level)

POINT JUDITH AREA

<u>Equivalent Hurricanes</u>	<u>Flood Stage at Breachway Entrance, M.S.L.</u>	<u>Point Judith Area of Proposed Protection</u>
Sept 1938	9.5	\$3,200,000
Aug 1954	9.1	\$2,920,000

ANNUAL LOSSES AND BENEFITS

G-6. GENERAL

The total benefits to the multiple-purpose plan in the Point Judith Project area comprise benefits from tidal-flood prevention, elimination of emergency costs, increased navigation and prevention of boat damage, beach erosion prevention, and increased utilization of lands.

G-7. AVERAGE ANNUAL TIDAL-FLOOD LOSSES

Recurring tidal-flood losses in the project area have been converted to average annual losses by correlating stage-loss and stage-frequency relationships to derive damage-frequency curves. The areas under the damage frequency curves, which have been plotted with damage as the ordinate and percent chance of occurrence in a

single year as the abscissa, is a measure of the average annual loss. The total average annual loss in the Point Judith Harbor protected by the project amounts to \$174,200.

G-8. AVERAGE ANNUAL FLOOD DAMAGE PREVENTION BENEFITS

Average annual benefits from the prevention of tidal-flood damages have been derived by determining the average annual losses under existing conditions and the average annual losses remaining after construction of the project. For benefit analysis the plan was divided into sections as shown on Plate G-1. A tabulation of benefits for each section is shown on Table G-3. The average annual flood-damage prevention benefits attributable to the plan total \$152,900.

TABLE G-3.

ANNUAL FLOOD-DAMAGE PREVENTION BENEFITS

SO. KINGSTOWN AND NARRAGANSETT, RHODE ISLAND

POINT JUDITH AREA

<u>Area</u> <u>So. Kingstown</u>	<u>Description</u>	<u>Annual Loss</u> <u>Pre-Project</u>	<u>Annual Loss</u> <u>Post Project</u>	<u>Flood Preven-</u> <u>tion Benefits</u>
I	Matunuck, East Matunuck and Succotash Road	18,500	1,300	17,200
II	Snug Harbor to Turner Cove	22,700	4,000	18,700
III	Turner Cove to northerly Town Line	<u>9,500</u>	<u>2,100</u>	<u>7,400</u>
	Subtotal	50,700	7,400	43,300
<u>Narragansett</u>				
IV	Jerusalem, Galilee and Sand Hill Cove	97,200	9,000	88,200
V	Great Island; Bluff Hill Cove to Welcome Cove	15,700	2,800	12,900
VI	Harbour Island; Welcome Cove to northerly Town Line	<u>10,600</u>	<u>2,100</u>	<u>8,500</u>
	Subtotal	123,500	13,900	109,600
	Totals	174,200	21,300	152,900

G-9. EMERGENCY COST BENEFITS

In addition to actual tidal-flood damage, many firms sustain significant losses by taking temporary protection measures following each hurricane warning whether flooding occurs or not. It is estimated that the 35 commercial establishments and the one industrial firm that are within the flood plan incur emergency costs of \$6,000 each hurricane warning. Also residential property owners who evacuate their personal belongings to higher elevations and pleasure craft enthusiasts that move their boats to safer locations incur costs estimated at \$5,000. The estimated benefits attributable to the plan of protection by elimination of these emergency costs amount to \$3,300 annually based on a frequency of 3 warnings every 10 years.

G-10. NAVIGATION AND PREVENTION OF BOAT DAMAGES

Boat damages were about \$3,500,000 when the Atlantic Tuna Tournament was wrecked in 1954 hurricane Carol; with the normal fleet in the harbor damages for a recurrence of Carol are estimated at about \$2,000,000. The plan is credited with \$50,000 annual benefits for prevention of boat damages. The annual benefits for navigation improvements are \$73,300, as given in Appendix D.

G-11. BEACH EROSION PREVENTION

The total annual benefit for the beach erosion portion of the plan is \$218,700 for the East Matunuck State Beach, as discussed in Appendix E.

G-12. ENHANCEMENT

In addition to damage prevention benefits, the project will make available for residential development some 46 acres of land on the easterly shore of Point Judith Pond and on Ram Island, presently susceptible to flooding by severe hurricanes. Adjoining land in the area is already being developed, mostly for year-round housing. Reflecting the already completed sections of new highway which link the area to Providence, the State capitol and industrial hub, and the planned highways which will soon bring the area to within a half hour's driving time of downtown Providence, the year-round population of Narragansett has increased by 50% in the past ten years. The Rhode Island Development Council, in a report entitled, "The Rhode Island Shore - A Regional Guide Plan Study, 1955-1970", issued in 1956, forecasts a population growth of 162% to 250% for Narragansett for the study period. The location of the land on the east side of the pond within five minutes driving time of Wakefield center and a divided lane highway to Providence makes it a prime area for early development. The recreational opportunities offered by Point Judith Pond add to the desirability of the area for residential purposes.

Allowing for areas devoted to access and odd lot sizes, it is estimated that 250 lots of 7,000 square feet (the minimum permitted

by zoning law) will be made available and will be rapidly developed when protection has been provided.

Information received from local officials and real estate interests in the towns bordering Point Judith Pond is that the present average price of lots in the area is from \$2,500 to \$3,000 for lots of 6,500 to 7,000 square feet. Based on past experience in the Scarboro section of Narragansett, the value of these lots can be expected to at least double in the next ten years.

Major development costs are not anticipated; there are some utilities already in the area and provision of the necessary extensions should not be too costly. Table G-4 below sets forth present value, development costs, future value and enhancement in the area.

TABLE G-4

ENHANCEMENT DEVELOPMENT

POINT JUDITH AREA

A. Present Value: 250 at \$2500	=	\$ 625,000
Area Development Cost	=	<u>136,000</u>
B. Investment		\$ 761,000
C. Future Value: 250 at \$5000	=	1,250,000
C minus B equals Enhancement	=	489,000

Present interest rates for loans for residential construction in the Point Judith Pond area are 6% for year-round type of construction and 6½% if summer type building is contemplated. As the area is suitable for and will likely be developed for year-round housing, an annual interest rate of 6% has been used in deriving the return on the increased values, resulting in an ultimate annual benefit of \$29,340.

The development can be expected to start as soon as the project is complete with a steady increase to the maximum by the fifteenth year. Expressed in terms of an equivalent annual benefit, this amounts to \$19,600.

G-13. SUMMARY OF BENEFITS

The overall total annual benefits attributable to the Water Resources Development plan is \$523,800. Of this amount, \$152,900 is for flood protection, \$3,300 is for the elimination of emergency costs, \$73,300 is for increased navigation, \$50,000 is for the prevention of boat damages, \$218,700 is for beach erosion control, \$19,600 is for increased utilization of land, and \$6,000 is for the reduction of loss of land at Matunuck Point.

G-14. GROWTH TRENDS IN POINT JUDITH AREA

The population growth of Rhode Island, percentage-wise, in the decade 1950-1960, was 8.6% compared with a percentage growth of 13% for the New England States as a whole and 18.5% for the entire country. While relatively small, percentage-wise, the effects of this growth are that the most densely populated state in the country with a density of 748 people/square mile in 1950 has a density of 800 people/square mile in 1960. This is based on gross area. On a basis of usable area, the proper figure is more probably in excess of 1,000 people/square mile. In the east central portion of the state, the density exceeds 4,000 people/square mile; in the Point Judith Pond area, the comparable figure is less than 200 people.

The slow but steady population growth, combined with the national trend of movement from urban cities to more open areas, will mean a large increase in population in the entire South County area of Rhode Island which is the locus of Point Judith Pond. During the past decade (1950-1960) Providence had a 16.5% loss in population at the same time that the less developed Kent County which bounds the area to the south and west had a population growth of 44.8%. Numerically, the gain in Kent County (34,856) amounted to 85% of the Providence loss (41,176). The major portion of this growth in Kent County took place in a southerly direction from Providence along Narragansett Bay and is already impinging on the South County area. This expansion to the south will continue and in combination with present growth in the area is the basis for the enhancement predicted for Narragansett in the 15-year period following completion of the project.

In a regional study entitled, "The Rhode Island Shore - A Regional Guide Plan Study - 1955-1970", prepared by the Rhode Island Development Council under a Federal Urban Planning Grant from the Urban Renewal Administration in 1955 a detailed study is included of the South Kingstown area. Noting local and regional factors which are influencing the area at present, and considering under construction or planned public and private projects which will be felt in the future, the study forecasts a population growth

of from 58 percent if low to 137 percent at optimum between the years 1955-1970. Some factors which entered into the study's projection were the expected early completion of a limited access highway (presently under construction) linking South Kingstown to Providence; the planned development of South Kingstown Industrial Park; the State of Rhode Island's plans for additional recreational development in the town and the growing trend toward year-round living in shore areas. Based on present economic activity in the area, an expected total growth of 60% for the period seems not unreasonable by 1970. Over a period of 50 to 100 years the population growth will be such that all suitable land in the project area will be in demand just from population pressure alone.

In considering the benefits to be realized at Point Judith Pond over a 100-year life project the following is to be noted:

Damages prevented benefits will be the same for the 100-year life project as for the 50-year.

On the Narragansett side of the pond all possible growth has already been discounted as an enhancement to take place within 15 years of the time the project is constructed.

On the South Kingston side of the pond there can be no growth without the project because of zoning regulations which prohibit the construction of structures susceptible to hurricane tidal flooding damage in the areas to be protected by the project.

After the project is constructed the need of such zoning will be obviated and some 43 acres of land, presently flood prone, will be available for higher use as residential or commercial property.

In evaluating the project on a basis of a 50-year life it seems likely that the availability of a sizeable acreage of contiguous flood free land, presently undeveloped, would preclude any great demand for the land now flood prone. The probable unwillingness of local authorities to modify a recently adopted zoning ordinance until there is proof of the project's effectiveness is also to be considered. Therefore, little or no enhancement can be counted on in this period. However, the previously noted population pressure will eventually result in a demand for the lower lying land and with a project life of 100 years some enhancement of this property can be expected.

To be conservative only 60% of the total land available was considered because of the irregular shape of the plots of available land; the requirements of access and circulation in these areas and the probability that not all of the land will be put to its highest use based on past practices in the area. 26 acres are considered the amount of land to be enhanced.

There is no sewage collection system in South Kingstown and no public water supply. Normal water supply in new areas is by wells and sewage disposal is by septic tank. Based on Board of Health regulations as to separation between water supply and sewage disposal facilities a minimum lot size of approximately 7,000 square feet is desirable for residential areas. On this basis 156 lots are available in the 26 acres.

Present assessed value of undeveloped shore land in South Kingstown is a nominal \$300 an acre with assessment representing 70% of valuation. It can be anticipated that as the contiguous areas are subdivided and developed the value of this shore land will approach \$1,200 an acre. Divided into six lots this represents a basic value of \$200/lot for pre-project conditions.

In Narragansett the ultimate value of a 7,000 square-foot lot was conservatively estimated at \$5,000. Due to the lack of public water and sewer systems in South Kingstown it is reasonable to assume that values will seldom exceed 80% of the Narragansett figure. This sets the ultimate value at \$4,000 a lot. Development costs are estimated at \$1,000 a lot for sewer and water (septic tank and driven well) and \$200 a lot for access and electric power.

Enhancement:

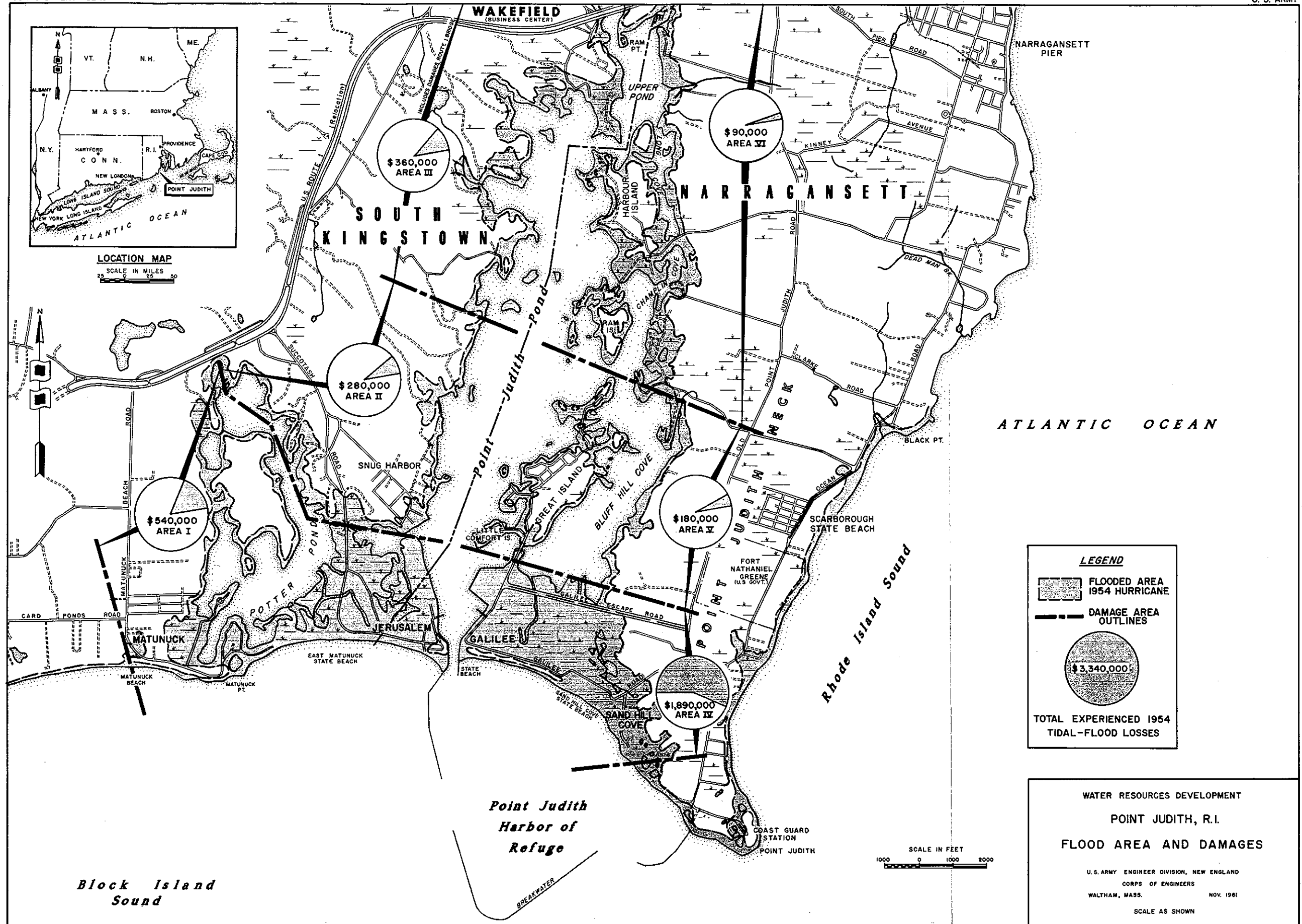
Original value of lot	\$ 200
Development Cost	1,200
Cost	<u>\$ 1,400</u>
Ultimate Value	\$ 4,000
Enhancement (per lot)	\$4,000 - \$1,400 = \$ 2,600
Total Enhancement 156 lots @ \$2,600	= \$405,600
Capitalized @ 6% = \$405,600 x .06	= \$24,336

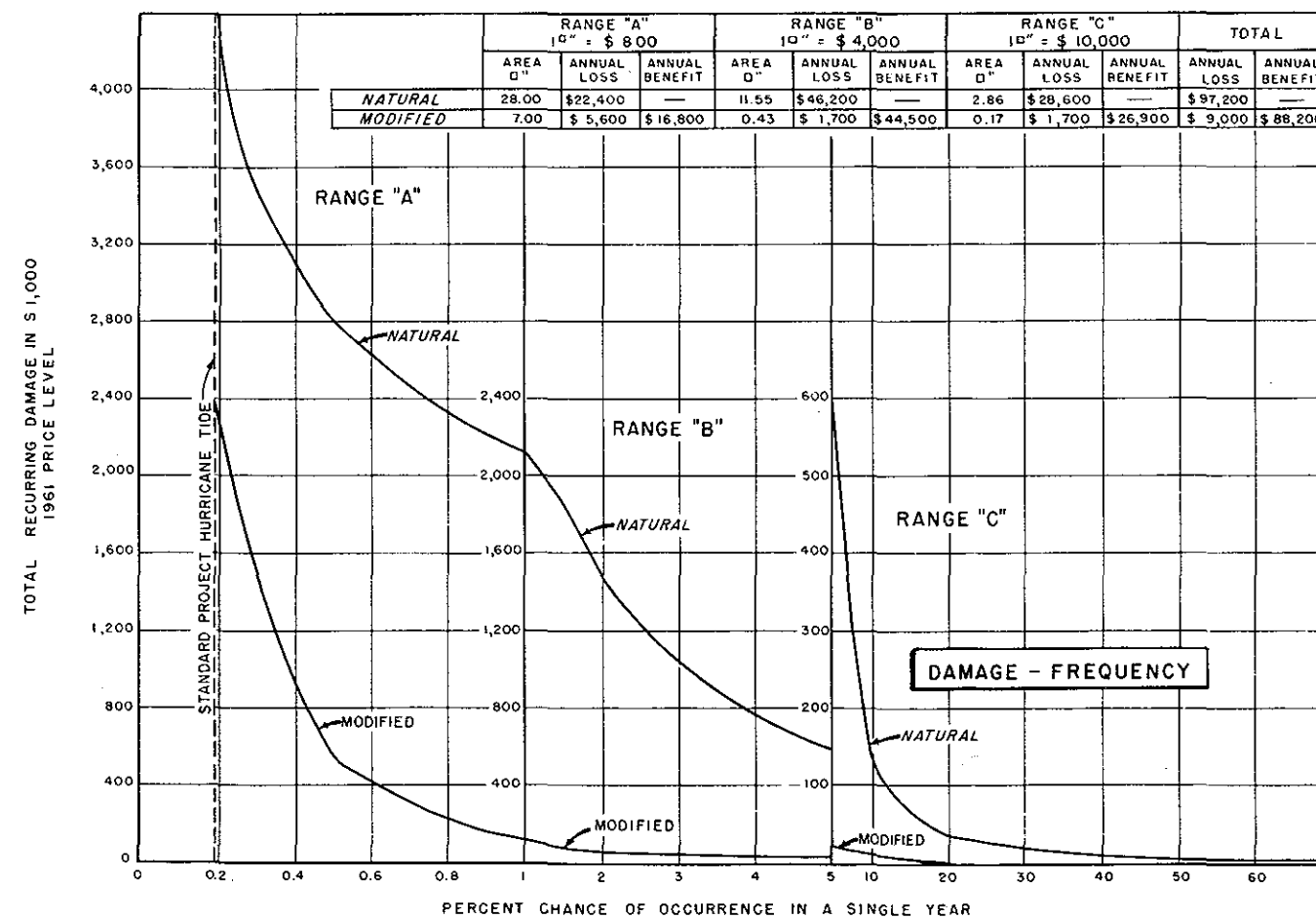
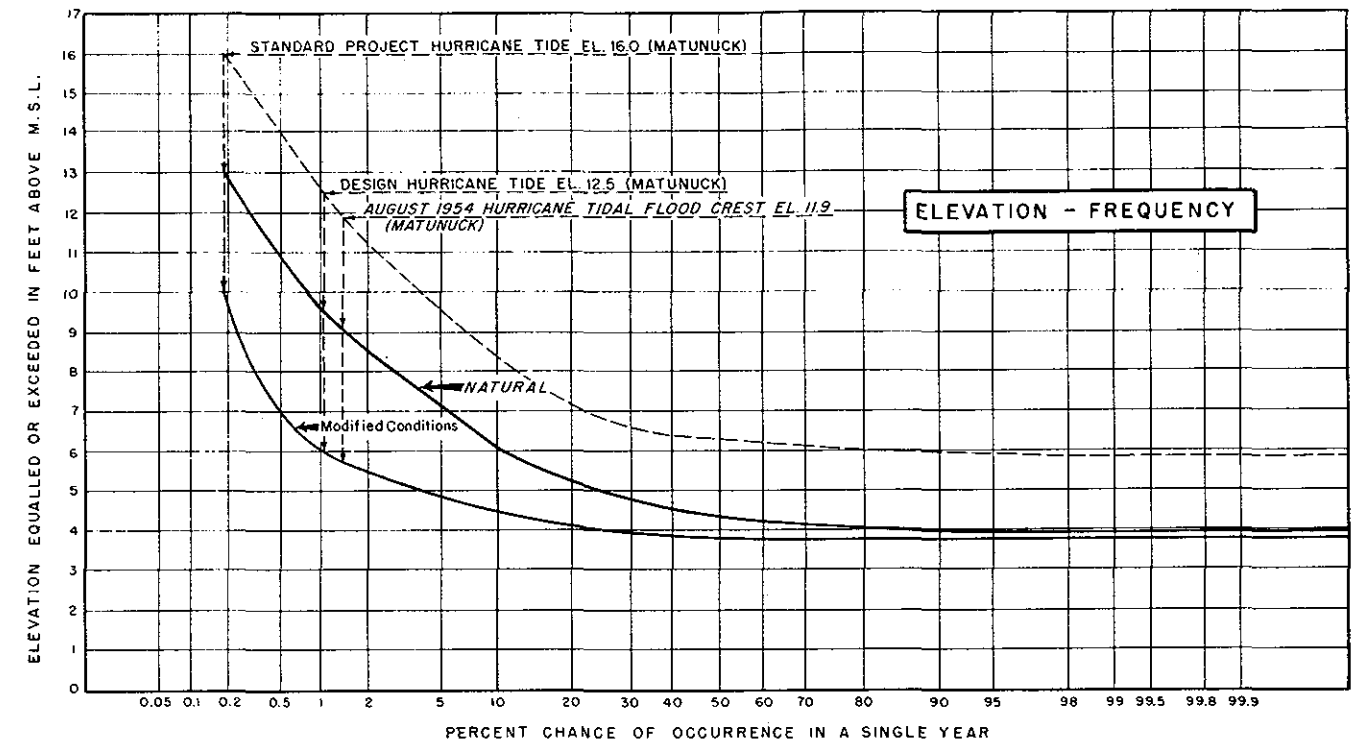
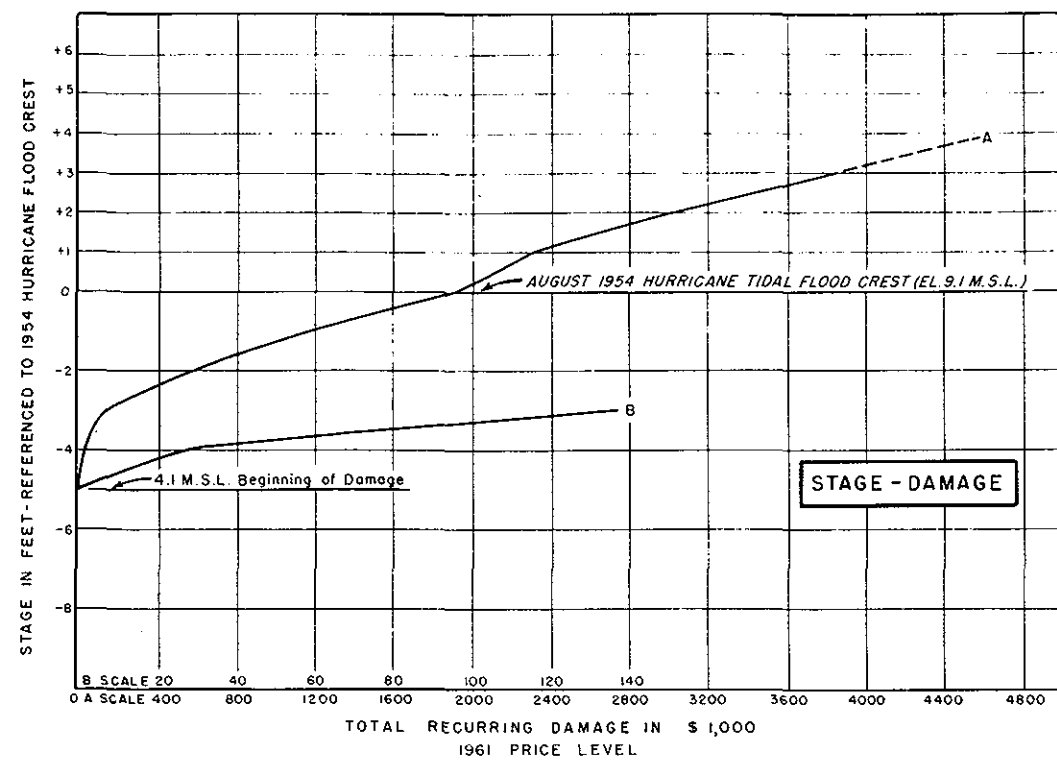
Average annual equivalent benefit by formula on page 2 of Appendix II to EM 1120-2-118 dated 16 November 1959.

$$E = aEf$$

and using a value of Ef for 6% and n = 100 taken from Table 4 on page 10 of Change 2 to the same appendix dated 19 December 1960.

$$E = \$24,336 \times .11764 = \$2,862.88 \text{ - Say } \$2,900 \text{ Annual Benefit.}$$





WATER RESOURCES DEVELOPMENT
POINT JUDITH, R.I.
TYPICAL CURVES FOR ECONOMIC ANALYSIS
AREA IV-JERUSALEM, GALILEE AND SAND HILL COVE
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS. NOV. 1961

APPENDIX H

PUBLIC HEARINGS AND VIEWS OF OTHER AGENCIES

APPENDIX H

APPENDIX H
PUBLIC HEARINGS AND VIEWS OF OTHER AGENCIES

TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
H-1	GENERAL	H-1
H-2	DIGEST OF PUBLIC HEARING	H-1
H-3	LETTERS OF COMMENT	H-1

APPENDIX H

PUBLIC HEARINGS AND VIEWS OF OTHER AGENCIES

H-1. GENERAL

This appendix presents a digest of the public hearings and includes available letters and statements indicating the views of other agencies and individuals, not represented at the hearing, on the plan of hurricane tidal flood protection, navigation improvements, and beach erosion control measures.

H-2. DIGEST OF PUBLIC HEARING

Public hearings were held by the Division Engineer at South Kingstown and Narragansett, Rhode Island, on 17 December 1958 and 6 June 1960, respectively to give all interested parties an opportunity to express their views concerning the character and extent of the improvements desired, and the need and advisability of their execution. In the 1958 hearing, to determine the need for additional navigation improvements, local interests:

- a. Emphasized the "tremendous growth of the Point Judith area" and the increase in commercial and recreational boating.
- b. Requested navigation improvement to meet present needs and future growth.
- c. Requested concurrent study of protection against flooding and wave action by restoring and raising the beaches and natural dunes.

A digest of the 1960 hearing is attached together with abstracts of correspondence pertaining to the recommended plan.

H-3. LETTERS OF COMMENT

- a. U. S. Department of Interior, Fish and Wildlife Service - letter signed by Mr. M. A. Marston, Acting Regional Director, dated 15 July 1960
- b. U. S. Department of Health, Education and Welfare, - Public Health Service letter signed by Mr. Lester M. Klashman, Acting Regional Program Director, Water Supply and Pollution Control, dated 27 March 1961.
- c. U. S. Department of Commerce, Bureau of Public Roads - letter signed by Mr. J. Westall, Division Engineer, dated 27 March 1961.

d. State of Rhode Island, Department of Agriculture and Conservation, Division of Fish and Game, letter signed by Mr. Thomas J. Wright, Chief, dated 10 March 1961.

e. State of Rhode Island, Department of Health, Division of Sanitary Engineering, letter signed by Mr. Walter J. Shea, Chief, dated 9 March 1961.

f. State of Rhode Island, Department of Public Works, Division of Parks and Recreation, letter signed by Mr. William H. Cotter, Jr., Chief, dated 15 March 1961.

g. Town of South Kingstown, Rhode Island, Town Clerk's Office, Wakefield, Rhode Island, letter signed by Mr. Foster R. Sheldon, Town Clerk, dated April 18, 1961.

h. State of Rhode Island, Rhode Island Development Council, (See minutes of Hearing, 6 June 1960, Ernest Friday).

i. State of Rhode Island, Department of Public Works, Division of Harbors and Rivers, (See minutes of Hearing, 6 June 1960, Henry Ise).

j. Town of Narragansett, Town Council, Narragansett, Rhode Island, letter signed by Mr. John A. Mulligan, Council Clerk, dated March 15, 1961.

DIGEST OF PUBLIC HEARING, NARRAGANSETT, RHODE ISLAND
JUNE 6, 1960

Speaker	Interest Represented	Protection Desired and Remarks
Mr. Henry Ise'	State of Rhode Island Div, of Harbors and Rivers	The project as described represents just about what is needed for protection. The report should contain the recommendation that the breakwater forming the Harbor of Refuge be repaired. The restriction of the Breachway will not unduly affect the currents. The straightening and deepening of the entrance channel will greatly improve conditions in the Breachway. All dredging for fill should be accomplished in areas where navigation improvements are desired. The Federal share of the navigation improvements both at Galilee and the Upper Pond should be greater than 50% because of the extensive commercial navigation in the area.
Mr. William H. Cotter, Jr.	State of Rhode Island Div. of Parks and Recreation	At East Matunuck State Beach the planned 17-foot dune and the wide beach are desirable. The use of eight groins in this area would create a hazardous condition for bathers; a reduction to four is suggested. The proposed sand dike at Sand Hill Cove would not create a problem; the widening of the beach at this elevation is desirable. The repair of the Harbor of Refuge breakwaters might reduce some of the erosion at Sand Hill Cove. The proposed construction at the Breachway will not seriously affect the operation of the small State beach on the east side.

E. Rex Coman

State Senator
Narragansett, R.I.

The future of the Town of Narragansett lies in the development of the residential communities. People cannot be expected to purchase property and invest money in homes unless adequate protection against hurricane tidal-flood damage is provided. Banks will not lend mortgage money in pontential damage areas. As a first step the breakwaters should be built longer and to a higher elevation than at present. The protection should be extended to include the entire Stanton Avenue development, east of Sand Hill Cove where there are some 52 homes at the present time. With the exceptions noted expressed approval of the plan.

Richard W. Caswell

State Representative
Narragansett, R.I.

Expressed agreement with the statements of Senator Coman. Requested clarification of terms "Federal" and "local" interests, to include the State of Rhode Island as a "local interest".

Eugene W. Winslow

President, Town Council
South Kingstown, R.I.

The town government and the townspeople appear to be in favor of most details of the plan. Due to the large commercial fishing industry, the Federal government should bear more than 50% of the costs of navigation improvements. Because of the large State investment in the area the State should bear a proportionately higher share of the local costs than the towns. Since

the hurricane damage is more serious in Narragansett than in South Kingstown, the former should bear a larger proportion of the local costs than the latter. My personal opinion is that the town government might make a payment of \$25,000 to \$50,000 toward the project. Feel that the people are very much in favor of the project and that the problems are all involved in local cost sharing.

William H. Knight

Chairman, So. Kingstown
Waterfront Resources Comm.

States for the record that the South Kingstown Waterfront Resources Committee is in favor of the project. Reported boat losses of \$3,480,000 in the area during Hurricane Carol, 1954 as compiled by a leading marine insurance underwriter.

N.W. Smith, Jr.

Secretary, South
Kingstown Waterfront
Resources Committee

Committee feeling is that the town is sustaining very serious damage in the form of erosion and storms going over the land. The State in the process of development of the beach, and private land owners have generally lowered the dunes and lowered the protection of the natural barrier in the area and this project is in effect a restoration of the natural barrier, namely the dunes and the Breachway. We feel that the project is of economic importance to the Town of Narragansett and some effort should be made to work out the details and live with them.

A.J. McKenzie

Harbormaster, South
Kingstown, R.I.
Member, South Kingstown
Water Resources Comm.

Feel very favorable toward project in general with some reservations. Lengthening of groins desirable to prevent clogging of channel of littoral material. A 50-50 split of first costs of navigation is not realistic because of the large commercial use of the navigation improvements particularly during hurricanes and bad storms.

Suggest a 70% or even 100% Federal share as boat traffic is at least 70% commercial. At least 50% of the boats hauled at Hansons Boat Yard in Wakefield are commercial. Registered objection to narrowing the Breachway opening to 150 feet unless the entrance channel is straightened.

Mr. Richard A. Colvin	President, Town Council Narragansett, R.I.	Previous discussions and plans showed dredging of channel connecting Long Cove with Champlin Cove. Why is this not included in present plan?
Mr. J. Andrew Walsh	Real Estate Harbor Island	Requests that dredging of channel - Long Cove - Champlin Cove be included in the plan.
Mr. Norman Durfee	Restaurateur Georges Restaurant Galilee, R.I.	Requests that barrier at Breachway be placed as far south as possible in order to obtain maximum use of parking lot for restaurant and beach patrons. Further requests that there be no vehicle ramp over barrier at State beach.
George E. Harley, Jr. Mrs. Rose Larose	Matunuck Point Businessmens Assn. Individual, Property Owner Matunuck Beach	All expressed disapproval of any plan to raise Matunuck Beach Road. Requested
Mr. James O. Watts	Attorney, Representing Earl and Phyllis Cardy, Property Owners, Matunuck Beach	that protection be provided by a dike along the shoreline to include all property on the south side of Matunuck Beach Road within the protected area. Value of land to be protected estimated at \$180,000.
Mr. Arthur P. Bove	Individual, Property Owner, Matunuck Beach	
Mr. John M. McAllister	Individual, Property Owner, Matunuck Beach	
Frederick W. Reichstetter Dr. Wm. J. McDermott	Representing Stanton Avenue Development at Sand Hill Cove (Seaweed Beach)	Requested the protection be extended on the easterly end to include entire development.

Ernest Friday	State of Rhode Island Development Council	Read statement placing Development Council on record as being in favor of the project.
Dr. Edward Damarjian	Individual, Property Owner Matunuck Point	Asked if protective structures would make conditions worse relative to water levels outside Breachway.
Roland E. Beauregard	Individual, Property Owner Sand Hill Cove-Point Judith	Requested extension of plan to Point Judith headland to afford protection for proposed development east of Sand Hill Cove.
Benjamin Davies	Individual, Property Owner Sand Hill Cove (Stanton Avenue)	Requested extension to include all property along Stanton Avenue.
Jacob Dykstra	Fisherman and President of Point Judith Fishermen's Assn.	Generally in favor of project and of narrowing of Breachway if straightened and there is no increase in the current.
George Boutilier	President, Great Island Improvement Assn.	Requested opening of Long Cove-Champlin Cove to increase circulation on Bluff Hill Cove area.
David Kenyon	Individual, Property Owner Champlin Cove	Said opening of Long Cove-Champlin Cove would tend to move pollution line further south.
Howard Satler	Individual, Property Owner Jerry Brown Farm Assn.	Concerned about locations of spoil disposal areas for dredged material.
George Rivera	Individual, Property Owner	Suggested alternate dikes.



ADDRESS ONLY THE
REGIONAL DIRECTOR

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
59 TEMPLE PLACE
BOSTON, MASSACHUSETTS

NORTHEAST REGION
(REGION 5)
MAINE
NEW HAMPSHIRE
NEW YORK
VERMONT
PENNSYLVANIA
MASSACHUSETTS
NEW JERSEY
RHODE ISLAND
DELAWARE
CONNECTICUT
WEST VIRGINIA

July 15, 1960

Division Engineer
New England Division
U. S. Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This preliminary report is in response to Mr. Leslie's letter of May 13, 1960 which had inclosed a notice of public hearing on June 6, 1960 regarding hurricane tidal protection, navigation and related improvements for the Point Judith Pond area, South Kingstown and Narragansett, Rhode Island. The purpose of this hearing in Narragansett, Rhode Island was to present the preliminary plans and obtain the views of interested parties on the various improvements. The Rhode Island Division of Fish and Game concurs in this report.

Your plan would provide protection against tidal flooding from hurricanes of the severity of the 1954 and 1938 storms, for the area from Matunuck Beach Road on the west to Seaweed Beach (Chestnut Avenue), about $3\frac{1}{2}$ miles east along the shore front. Protection would extend northward to the head of the Point Judith Pond near Wakefield. This plan of protection would include measures for: (1) beach raising and widening, (2) dune restoration, (3) raising roads to form protective dikes, and (4) modification of the Breachway to reduce the flood levels in Point Judith and Potter Ponds.

The plan of improvement under consideration in the interest of navigation includes the following:

- (1) Deepen entrance channel to Point Judith Pond from present depth of 15 feet to a depth of 18 feet.
- (2) Provide a channel 6 feet deep and anchorage of the same depth in the cove west of Gooseberry Island.

- (3) Deepen and widen the existing channel through Point Judith Pond to Wakefield from its present depth of 6 feet to a depth of 8 feet, and its present width of 100 feet to a width of 150 feet. An alternate route of the same dimensions to the east of the existing channel is also being studied.
- (4) Enlarge anchorage at Wakefield.

It is our understanding that specific source locations of sand material for beach raising and widening and dune restoration by hydraulic dredging have not been selected. Furthermore, that spoil disposal sites have not been selected for disposition of spoil material resulting from navigation improvements. It is these elements which could affect the fish and wildlife resources of the project area.

We conclude that there would be no significant adverse effects upon the fish and wildlife resources as a result of the actual placement of sand fill material on existing beaches and dunes, the raising of roads to form protective dikes, the actual deepening and widening of existing channels, the provision of a channel and anchorage in the cove west of Gooseberry Island, and the enlarging of the anchorage at Wakefield.

However, significant adverse effects upon the fish and wildlife resources could be involved in dredging activities which are associated with beach and dune sand fill material, spoil disposal sites associated with channel and anchorage improvements, and the modification of the Breachway. The alternate channel route which is proposed in Point Judith Pond could have direct adverse effects by causing outright destruction of shellfish and permanent removal of productive shallow-water habitat with the substitution of less desirable deep-water conditions.

Destruction of soft clam, quahog, and scallop resources of the project area would result from dredging activities in Potter Pond and Point Judith Pond for beach raising and widening and dune restoration. We would object to the use of tidal wetlands and marshes, mud flats, and shallow water areas as spoil disposal sites which might be utilized in connection with spoil material from navigation and anchorage improvements. Shellfish, finfish, waterfowl, and shorebird resources in particular are dependent upon this type of habitat during a portion of or throughout their entire existence. The effects of the modification of the Breachway on the fish and wildlife resources cannot be determined at this time. Restriction of the normal tidal flow into the project area could have adverse effects upon the fish and wildlife resources. More detailed information on all the above plans of improvement will be necessary in order to more adequately determine project effects on the fish and wildlife resources.

There may be some opportunities in connection with spoil disposal activities to contribute to the conservation of fish and wildlife resources of the project area which could provide some mitigation for damages to these resources or might also provide for their further development. Utilizing spoil material to create shoal conditions in deep-water areas would make the habitat situation more attractive for waterfowl and possibly for the production of shellfish. Project related developments and improvements would be least damaging to the fish and wildlife resources if we are given sufficient advance notification of dredging sites and spoil disposal sites, or mutual selection of these sites is conducted by your Division, this Bureau, and the Rhode Island Division of Fish and Game.

To adequately ensure minimum project occasioned losses and maximum project benefits a detailed study of the fish and wildlife resources of the project area will be required. The results of such a study will relate the existing fish and wildlife resources to the dredging and spoil disposal activities of the project. The effects of the modification of the Breachway upon fish and wildlife resources will also be determined.

We recommend:

- (1) That dredging for channel and anchorage improvements and beach and dune sand fill material be limited to those sites which would be least damaging to the fish and wildlife resources of the project area. These sites should be determined in cooperation with the Rhode Island Division of Fish and Game and the U. S. Fish and Wildlife Service.
- (2) That spoil disposal sites selected as a result of navigation and anchorage improvements be decided upon in cooperation with the Rhode Island Division of Fish and Game and the U. S. Fish and Wildlife Service.
- (3) That a detailed study be made of the fish and wildlife resources of the project area by this Bureau.

The opportunity to report on this study is much appreciated.

Sincerely yours,



M. A. Marston
Acting Regional Director

DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
REGIONAL OFFICE
REGION 11
42 BROADWAY
NEW YORK 4, N. Y.

PUBLIC HEALTH SERVICE

March 27, 1961

Refer to: 24:SE

Brigadier General S. A. Potter, Jr.
Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear General Potter:

Reference is made to your letter of March 2, 1961 relative to studies for the determination of a plan of protection against hurricane tidal flooding and for navigation improvements in the Point Judith Pond area of the Towns of South Kingstown and Narragansett, Rhode Island.

We have consulted with the Division of Sanitary Engineering of the Rhode Island Department of Health on this matter. It is felt that this plan will have little effect on the pollution problem in Point Judith Pond. It should be noted, however, that the establishment of additional small boat anchorage areas such as those proposed to be located adjacent to Galilee and at Snug Harbor may require that the surrounding areas be closed to the taking of shellfish in order to assume conformance with the U. S. Public Health Service recommendations.

For the Regional Engineer.

Sincerely yours,

Lester M. Klashman
L.M.K.

Lester M. Klashman
Regional Program Director
Water Supply & Pollution Control

CONNECTICUT
MAINE
MASSACHUSETTS
NEW HAMPSHIRE
NEW JERSEY
NEW YORK
RHODE ISLAND
VERMONT

U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
REGION ONE

316 Post Office Annex
Providence 3, Rhode Island
March 27, 1961

Your File No. NEDGW

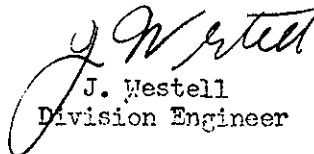
• Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
422 Trapelo Road
Waltham 54, Mass.

Dear Sir:

We have reviewed the attachments contained in your letter dated March 2, 1961 relative to the plan of protection against hurricane tidal flooding and for navigation improvements in the Point Judith Pond area of the Towns of South Kingstown and Narragansett, Rhode Island.

To our knowledge there are no contemplated Federal-aid highway improvements in the immediate vicinity of your projects and it appears your proposals will have no adverse effect on the existing Federal-aid Secondary Highways in the area.

Very truly yours,


J. Westell
Division Engineer



STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF AGRICULTURE & CONSERVATION
DIVISION OF FISH AND GAME
VETERANS' MEMORIAL BUILDING, PROVIDENCE 3, R. I.

JOHN L. REGO
DIRECTOR

March 10, 1961

THOMAS J. WRIGHT
CHIEF

Seymour A. Potter, Jr.
Brigadier General, USA
Division Engineer
U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Mass.

Dear General Potter:

The following are our comments from a fish and wildlife viewpoint, on the plans for the hurricane tidal flooding and navigation improvements in the Pt. Judith Pond Area.

At this time we can see no adverse affects of any of the improvements on shellfish other than that which is directly in the path of the navigation channel and possibly immature shellfish that cannot tolerate the silt that by necessity will be roiled up in the process of dredging.

There is considerable danger in the disposal of dredged material to wildlife habitat especially as it concerns salt marshes. It is understood that most of the material will be used in building the dike, however, where this is not the case we could assist in choosing sites that would do the least damage to wildlife habitat.

Very truly yours,

Thomas J. Wright, Chief
Division of Fish & Game



STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF HEALTH
STATE OFFICE BUILDING, PROVIDENCE 2

DIRECTOR OF HEALTH

~~JOSEPH E. CANNON, M.D., M.P.H.~~
Joseph E. Cannon, M.D., M.P.H.

DIVISION OF SANITARY ENGINEERING
WALTER J. SHEA, CHIEF

March 9, 1961

U. S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Attention of Seymour A. Potter, Jr.
Brigadier General, USA
Division Engineer

Gentlemen:

The proposed plan for protection of the Point Judith Pond area against hurricane tidal flooding and for navigation improvements in Point Judith Pond has been reviewed.

It is concluded that this plan will have little effect on the pollution problem in Point Judith Pond. It should be noted, however, that the establishment of additional small boat anchorage areas such as those proposed to be located adjacent to Galilee and at Snug Harbor may require that the surrounding areas be closed to the taking of shellfish. Such action would be in conformance with the U. S. Public Health Service recommendations.

Yours very truly,

Walter J. Shea, Chief
Division of Sanitary Engineering

WJS:ep

cc: Mr. Sylvan C. Martin, Regional Engineer
Public Health Service
New York, New York

NARRAGANSETT
TOWN COUNCIL



NARRAGANSETT, RHODE ISLAND

March 15, 1961

Seymour A. Potter, Jr., Brigadier General, USA
Division Engineer
Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

Re: File No. NEDGW

At a recessed meeting of the Town Council of the Town of
Narragansett held on Friday, March 10, A. D. 1961 it was

VOTED: That the Town of Narragansett endorse the U. S. Army
Engineers Protection Plan against Hurricane Tidal
Flooding and for Navigation Improvements in the
Point Judith Pond area of the Town of Narragansett.

The Town of Narragansett would be willing to
participate with the Federal Government in the cost
of the work if the project should be approved by
Congress.

Very truly yours,

John A. Mulligan
Council Clerk

JAM:ekp